

# Central Bank Transparency and the Signal Value of Prices<sup>1</sup>

Stephen Morris  
Princeton University

Hyun Song Shin  
London School of Economics

*Third Version*

September 2005

<sup>1</sup>Paper presented at the September 2005 meeting of the Brookings Panel on Economic Activity. We thank Bill Brainard, Ben Friedman, George Perry and Chris Sims for their comments and guidance. We also thank Marios Angeletos, Alan Blinder, Christian Hellwig, Anil Kashyap, Don Kohn, Chris Kent, Phil Lowe, Ellen Meade, Lars Svensson and T. N. Srinivasan for comments at various stages of the project.

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 touches on whether a central bank should publish its forecasts and whether it should have a publicly announced numerical target for inflation. 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.<sup>1</sup> However, one issue seems to have received less attention than 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 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

---

<sup>1</sup>See Kuttner (2004) 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).

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 Policy".

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.

## Informational Efficiency

Informational efficiency can be expected to have large welfare consequences. There are two broad channels - the allocational role of financial market prices in guiding investment decisions, and the information revealed by market outcomes as a guide to the central bank's optimal control problem. We take them in turn.

Financial market prices have a large impact on the level and type of investments undertaken. For central bankers, the allocational role of the yield curve in determining the duration of investment projects makes is of particular importance. Irving Fisher in his *Theory of Interest* (Fisher (1930)) gives the example of three possible uses for a plot of land - for forestry, farming or strip mining. The interest rate used to discount future cash flows largely determines the ranking of the three projects. Long duration projects such as forestry, where the bulk of the payoffs arrive in the distant future,

do best in an environment of low interest rates. When interest rates are high, short-duration projects like strip mining dominate. Since investment decisions are often difficult to reverse, distortions to investment can have a lingering effect long after the initial misallocations.

The current debate in the U.S. on the booming residential housing market and the appearance of “exotic” mortgage products that back-load repayments hinge on the correct pricing of long-term cash flows. If long-term interest rates are low, wage income in the distant future is given large weight, and even exotic mortgage products seem viable when backed by the large present values of wage income. For central bankers who must also keep a vigilant eye on overall financial stability, the allocational role of financial market prices take on great significance.

The allocational role of financial market prices is not limited to the yield curve as revealed in the prices of fixed income securities. New economy stocks that promise high payoffs in the distant future are the prime example of long duration projects. In the same way that high prices of long-duration fixed income assets push down long-term interest rates, high stock prices lower the implicit discount rate on dividends paid by stocks. Polk and Sapienza (2002) and Chen, Goldstein and Jiang (2005) document evidence that investment is sensitive to the information conveyed by stock prices. Anecdotal stories of formerly staid power companies venturing into telecoms and other more fashionable business areas and then coming up short of expectations has been a constant theme after the bursting of the technology bubble.

Central bankers have a large impact on financial markets. Indeed, it could be argued that the central bank’s impact can sometimes be *too* large. By the nature of the problem, it is difficult to gauge whether the reactions in the financial market is excessive or justified by the fundamentals. However,

the paper by George Perry (2005, this volume) provides some rare, tantalizing evidence that market prices may be distorted by anticipation of central bank actions.

The evidence comes from the contrasting market reactions to two sets of official data on the labor market. The Current Population Survey of Households (the “household survey”) provides snapshots of the labor market from surveys of households, while the Current Employment Statistics of payrolls of non-farm businesses (the “non-farm payroll survey”) provide snapshots from surveys of 400,000 businesses. Perry (2005) shows that the two measures are roughly comparable in terms of their ability to track broad labor market conditions, and a simple average of the two does well in combining the informational content of both series.

However, the financial markets certainly do not accord equal weight to the two series. The non-farm payroll numbers are given far greater weight, and are much anticipated by market participants. Fleming and Remolona (2000) document the sometimes dramatic reactions in the bond market to the non-farm payroll numbers. The fact that the Federal Reserve is known to accord more weight to the non-farm payroll survey undoubtedly plays on the minds of the market participants. Given the importance of *others’* reactions to news, the fact that others take note of the announcement is reason enough for me to take note. Thus, the contrasting reactions to the two labor market series may be attributable largely to the background presence of the central bank. Keynes’s “beauty contest” analogy comes to mind, and we will return to this below.

Perry’s (2005) findings echo a very similar phenomenon from an earlier era - the exaggerated reactions 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.

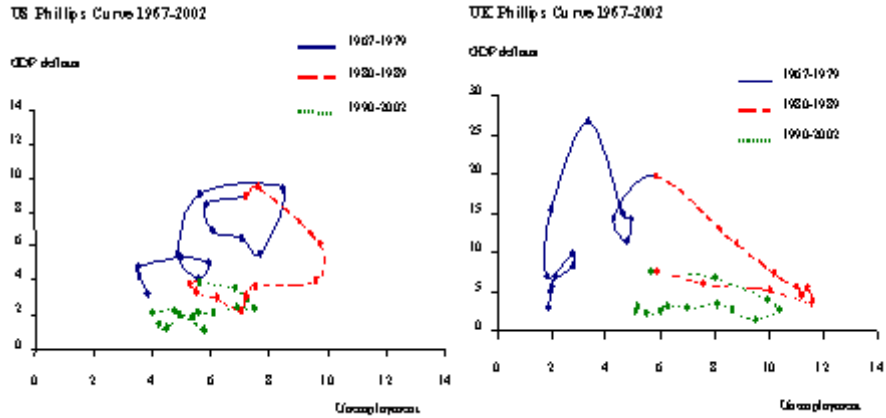
The evidence for the heightened reaction to money stock announcements in the early 1980s is documented in Roley (1983), Cornell (1983) and Roley and Walsh (1985)). Although the Federal Reserve has published weekly estimates for monetary aggregates for some time (and continues to do so today), the announcements 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 lightning rod that moves markets.

We now turn to the second channel through which informational efficiency may have an impact on economic welfare. In order for the central bank to steer the economy, it must have good information on the current state of the economy - in particular, how closely the economy is running to capacity. If the signals reaching the central bank are not informative, the control problem will be made more difficult.

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. Here, the informational efficiency of prices pertain to *goods* prices, rather than *asset* prices.

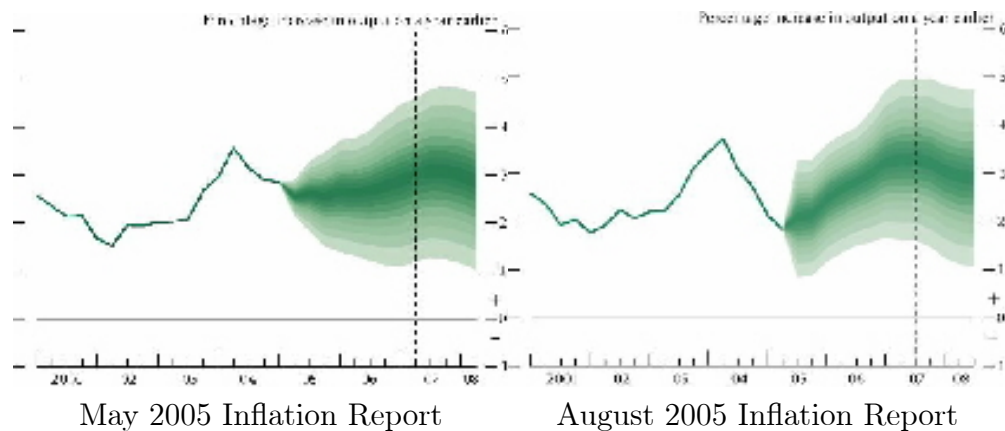


US Phillips Curve 1967-2002

UK Phillips Curve 1967-2002

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.<sup>2</sup>

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. It is more a “hammer” than a “fan”. 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.

The Bank of England’s *Inflation Report* for August 2005 describes the divergence between official statistical estimates of GDP and those obtained through business surveys, especially for the service sector. If the survey respondents put excessive weight on the prevailing conventional wisdom on the

<sup>2</sup>See the opinion piece in the *Financial Times* on August 10th 2005 “Bank of England needs to re-examine its forecasts” by Geoffrey Dicks.

level of economic activity, then the survey would be far less informative of current conditions. Sims's (2003) notion that economic agents exercise "rational inattention" in which they economize on information gathering would exacerbate the deterioration of information value.<sup>3</sup>

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 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.

Much evidence has been accumulating recently that the publication by central banks of numerical targets for inflation has been associated with a more effective anchoring of inflation expectations.<sup>4</sup> 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 value. They reveal very little to observers who look to them for signs of underlying shifts or trends in the economy. When informational efficiency emerges as a concern,

---

<sup>3</sup> See also Mackowiak and Wiederholt (2005) who show how Sim's (2003) framework can be used to explain the simultaneous occurrence persistence average prices, but large shifts in subsets of prices.

<sup>4</sup>Kuttner (2004), Ball and Sheridan (2003).

well-anchored expectations cease to be unambiguously desirable.

Mankiw, Reis and Wolfers (2004) examine the *dispersion* of inflation expectations in survey data and find that inflation expectations have become more concentrated around the mean. Levin, Natalucci and Piger (2004) investigate how well the mean inflation expectations have been anchored, also from 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:

$$\Delta\pi_{it}^q = \lambda_i + \beta\Delta\bar{\pi}_{it} + \varepsilon_{it} \quad (1)$$

where  $\pi_{it}^q$  is the expectation (formed at date  $t$ ) of inflation  $q$  years ahead in country  $i$ .  $\bar{\pi}_{it}$  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.

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 inflation 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.

By the nature of the problem, it is difficult to bring empirical evidence to bear on whether the central bank’s information has, indeed, deteriorated. Thus, at best, our argument is conjectural and speculative. However, we show in a later theoretical section that the information precision of the central

bank will depend, in general, on the disclosure regime. The more the central bank discloses, the less precise its signals will be. The “fan charts” of the central bank become fatter, and sometimes considerably so when it chooses to disclose more. We also return to the Bank of England’s experience in 2005 in the closing section for some clues on what kind of evidence we might look out for if we are interested in the question of informational precision for the central bank.

The theme explored in this essay is the tension between managing expectations and the impaired signal value of such managed expectations - both for financial market prices and for goods prices. 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 informational 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 concentrated 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 deliberately 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 modern 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 informational 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 relatively better informed than any *particular* agent out there in the economy. Indeed, the central planner could have an absolute advantage over any particular 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 forecasters 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. 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).

But there are reasons why improved public information - while privately valuable to the decision maker receiving it - might not be valuable to society. If the private information of market participants is to be revealed to other market participants, the private information must be reflected in market outcomes. If public information leads market participants to ignore downplay their private information in their actions, the market will reveal less new information about market conditions. Thus there is an informational externality generated by public signals.

This effect is further exacerbated if 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 lightning 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<sup>5</sup>, we explored the tradeoffs that result in such a setting by examining the outcome of a collective decision problem reminiscent of 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

---

<sup>5</sup>Morris and Shin (2002)

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 pronounce-

ments 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".

## 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:

$$a_i = (1 - r) E_i(\theta) + r E_i(\bar{a}) \quad (2)$$

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*

$$y = \theta + \eta \tag{3}$$

where  $\eta$  is normally distributed, independent of  $\theta$ , with mean zero and variance  $\sigma_\eta^2$ . 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  $\sigma_\eta^2$ . Hence,  $i$ ’s optimal action is

$$a_i(y) = (1 - r) E(\theta|y) + r \int_0^1 E(a_j|y) dj \tag{4}$$

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

$$a_i(y) = y \tag{5}$$

for all  $i$ . The average action is then  $y$  and the distance between  $a_i$  and  $\theta$  is

$$E[(y - \theta)^2 | \theta] = \sigma_\eta^2$$

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*:

$$x_i = \theta + \varepsilon_i \tag{6}$$

where noise terms  $\varepsilon_i$  are normally distributed with zero mean and variance  $\sigma_\varepsilon^2$ , 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

$$\begin{cases} \alpha = \frac{1}{\sigma_\eta^2} \\ \beta = \frac{1}{\sigma_\varepsilon^2} \end{cases} \quad (7)$$

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

$$E_i(\theta) = \frac{\alpha y + \beta x_i}{\alpha + \beta} \quad (8)$$

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

$$a_j = \kappa x_j + (1 - \kappa) y. \quad (9)$$

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

$$\begin{aligned} E_i(\bar{a}) &= \kappa \left( \frac{\alpha y + \beta x_i}{\alpha + \beta} \right) + (1 - \kappa) y \\ &= \left( \frac{\kappa \beta}{\alpha + \beta} \right) x_i + \left( 1 - \frac{\kappa \beta}{\alpha + \beta} \right) y \end{aligned}$$

Agent  $i$ 's optimal action is

$$\begin{aligned}
a_i &= (1-r) E_i(\theta) + r E_i(\bar{a}) \\
&= (1-r) \left( \frac{\alpha y + \beta x_i}{\alpha + \beta} \right) + r \left( \left( \frac{\kappa \beta}{\alpha + \beta} \right) x_i + \left( 1 - \frac{\kappa \beta}{\alpha + \beta} \right) y \right) \\
&= \left( \frac{\beta(r\kappa + 1 - r)}{\alpha + \beta} \right) x_i + \left( 1 - \frac{\beta(r\kappa + 1 - r)}{\alpha + \beta} \right) y
\end{aligned} \tag{10}$$

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

$$a_i = \frac{\alpha y + \beta(1-r)x_i}{\alpha + \beta(1-r)} \tag{11}$$

and the average action is

$$\bar{a} = \frac{\alpha y + \beta(1-r)\theta}{\alpha + \beta(1-r)}. \tag{12}$$

First observe that the larger is  $\alpha$ , the further away is the average action from  $\theta$ . This is true even if  $r = 0$ . However, if  $r > 0$ , then even less weight is put on the true state and even more weight is put on the public signal.

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

$$a_i = (1 - r) E_i(\theta) + r E_i(\bar{a}) \quad (13)$$

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

$$\begin{aligned} a_i &= (1 - r) E_i(\theta) + (1 - r) r E_i(\bar{E}(\theta)) + (1 - r) r^2 E_i(\bar{E}^2(\theta)) + \dots \\ &= (1 - r) \sum_{k=0}^{\infty} r^k E_i(\bar{E}^k(\theta)) \end{aligned} \quad (14)$$

In order to evaluate this expression, we must solve explicitly for  $E_i(\bar{E}^k(\theta))$ . Recall that player  $i$ 's expected value of  $\theta$  is:

$$E_i(\theta) = \frac{\alpha y + \beta x_i}{\alpha + \beta} \quad (15)$$

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

$$\bar{E}(\theta) = \int_0^1 E_i(\theta) di = \frac{\alpha y + \beta \theta}{\alpha + \beta}$$

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

$$\begin{aligned} E_i(\bar{E}(\theta)) &= E_i\left(\frac{\alpha y + \beta \theta}{\alpha + \beta}\right) \\ &= \frac{\alpha y + \beta \left(\frac{\alpha y + \beta x_i}{\alpha + \beta}\right)}{\alpha + \beta} \\ &= \frac{((\alpha + \beta)^2 - \beta^2) y + \beta^2 x_i}{(\alpha + \beta)^2} \end{aligned}$$

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

$$\begin{aligned}\bar{E}^2(\theta) &= \bar{E}(\bar{E}(\theta)) \\ &= \frac{((\alpha + \beta)^2 - \beta^2)y + \beta^2\theta}{(\alpha + \beta)^2}\end{aligned}$$

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  $\bar{E}^k(\theta) = (1 - \mu^k)y + \mu^k\theta$  where  $\mu = \beta/(\alpha + \beta)$ , and

$$\begin{aligned}a_i &= (1 - r) \sum_{k=0}^{\infty} r^k [(1 - \mu^{k+1})y + \mu^{k+1}x_i] \\ &= \left(1 - \frac{\mu(1 - r)}{1 - r\mu}\right)y + \left(\frac{\mu(1 - r)}{1 - r\mu}\right)x_i \\ &= \frac{\alpha y + \beta(1 - r)x_i}{\alpha + \beta(1 - r)}\end{aligned}$$

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), although for the reasons to be discussed below, we favor another interpretation of the decision rule.

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:

$$q_i^s = b(p_i - E_i(\bar{p})) \quad (16)$$

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  $E_i(\cdot)$  denotes the expectation with respect to the information available to residents of island  $i$ .

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

$$q_i^d = E_i(\theta) - p_i \quad (17)$$

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

$$p_i = (1 - r) E_i(\theta) + r E_i(\bar{p}) \quad (18)$$

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.

Although the outward form of (18) conforms to the beauty contest decision rule, the fundamental variable  $\theta$  in the original version of the island economy model is something that the central bank has full control over. Thus, learning about  $\theta$  is not an issue, and so the informational role of prices has no part to play in the analysis.

A more appropriate interpretation of the pricing rule (18) is in terms of the price-setting decisions of firms who have some market power due to

the imperfect substitutability between goods. Woodford (2003a) has popularized this interpretation of the beauty contest rule. In this context,  $\theta$  represents the underlying marginal cost conditions for the firms, which also corresponds to the output gap under some simplifications (Gali and Gertler (1999)). 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:

$$p_i = E_i p + \xi E_i \chi \tag{19}$$

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.<sup>6</sup>

Rewriting (19) in terms of nominal marginal cost, defined as  $\theta \equiv \chi + p$ , we have

$$p_i = (1 - \xi) E_i p + \xi E_i \theta \tag{20}$$

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

---

<sup>6</sup>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).

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

$$p_t = \bar{E}_t \bar{E}_{t+1} \cdots \bar{E}_{t+h} \theta_{t+h} \quad (21)$$

where  $p_t$  is the price of a financial asset at  $t$ ,  $\theta_{t+h}$  is the fundamental payoff at date  $t+h$ , and  $s_t$  is a noise term. 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,

$$\begin{aligned} p_t &= \bar{E}_t \bar{E}_{t+1} \cdots \bar{E}_{t+h} \theta_{t+h} \\ &\neq \bar{E}_t \theta_{t+h} \end{aligned} \quad (22)$$

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 ex-

pectation 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  $t \in \{\dots - 2, -1, 0, 1, 2, \dots\}$ . The fundamentals  $\{\theta_t\}$  evolve as a Gaussian random walk:

$$\theta_t = \theta_{t-1} + \phi_t \tag{23}$$

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:

$$a_{it} = (1 - r) E_{it}(\theta_t) + r E_{it}(\bar{a}_t) \quad (24)$$

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:

$$z_t = \bar{a}_{t-1} + \psi_t \quad (25)$$

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  $\{\dots, z_{t-2}, z_{t-1}, z_t\}$ . We are interested in the central bank's information precision at date  $t$  as measured by

$$\text{Var}(\theta_t | z_t, z_{t-1}, \dots)$$

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

$$\frac{\alpha_t \hat{z}_t + \gamma z_{t+1}}{\alpha_t + \gamma} \tag{26}$$

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

$$\begin{aligned} \frac{1}{\alpha_{t+1}} &= \text{Var}(\theta_{t+1}|z_{t+1}, \hat{z}_t) \\ &= 1 + \frac{1}{\alpha_t + \gamma} \end{aligned} \tag{27}$$

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

$$\alpha \left( 1 + \frac{1}{\alpha + \gamma} \right) = 1 \tag{28}$$

## 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

$$\{x_{it}, z_t, z_{t-1}, \dots\} \tag{29}$$

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:

$$a_{it} = \frac{\alpha_t \hat{z}_t + (1-r)\beta x_{it}}{\alpha_t + (1-r)\beta} \quad (30)$$

By taking the average across  $i$  in (30), the average action is

$$\begin{aligned} \bar{a}_t &= \frac{\alpha_t \hat{z}_t + (1-r)\beta \theta_t}{\alpha_t + (1-r)\beta} \\ z_{t+1} - \psi_{t+1} &= \frac{\alpha_t \hat{z}_t + (1-r)\beta \theta_t}{\alpha_t + (1-r)\beta} \end{aligned}$$

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:

$$s_{t+1} \equiv \left(1 + \frac{\alpha_t}{(1-r)\beta}\right) z_{t+1} - \frac{\alpha_t}{(1-r)\beta} \hat{z}_t \quad (31)$$

which is orthogonal to  $\{z_\tau\}_{\tau \leq t}$ . 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

$$\frac{\alpha_t \hat{z}_t + \hat{\gamma}_t s_{t+1}}{\alpha_t + \hat{\gamma}_t} \quad (32)$$

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.

$$\begin{aligned} \frac{1}{\alpha_{t+1}} &= 1 + \frac{1}{\alpha_t + \hat{\gamma}_t} \\ &= 1 + \frac{1}{\alpha_t + \gamma \left( \frac{(1-r)\beta}{\alpha_t + (1-r)\beta} \right)^2} \end{aligned} \quad (33)$$

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

$$\alpha \left[ 1 + \frac{1}{\alpha + \gamma \left( \frac{(1-r)\beta}{\alpha + (1-r)\beta} \right)^2} \right] = 1 \quad (34)$$

## Comparing the Regimes

Comparing the steady state information precision levels in the two regimes given by (28) and (34), we can see that steady state precision is lower under the disclosure regime since the expression in square brackets in (34) is larger than  $1 + \frac{1}{\alpha + \gamma}$ . For parameter values<sup>7</sup>  $r = 0.85$  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.

---

<sup>7</sup>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  $\xi$ .

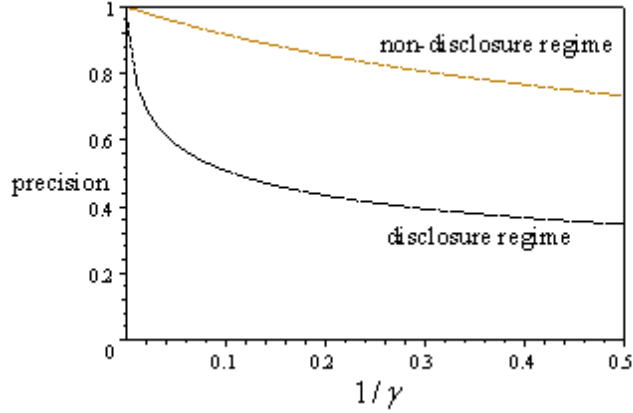


Figure 1: Precision of central bank information

It is worth noting that the deterioration of the central bank’s signal value under the disclosure regime holds even when  $r = 0$ , so that there are no coordination elements, although coordination elements exacerbate the effect. We return to this issue below.

It is also apparent from the implicit formula (34) 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 learns by observing what the individual agents do. The reason why  $\beta$  enters in this relation is because the aggregate actions  $\bar{\alpha}_t$  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

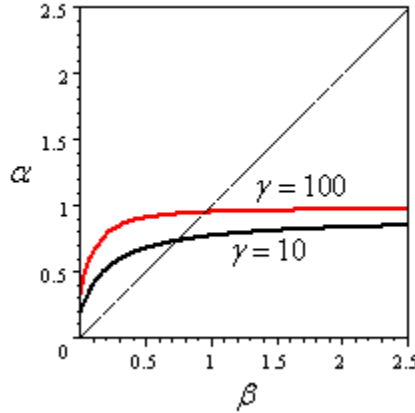


Figure 2:  $\alpha$  as a function of  $\beta$  in disclosure regime

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 (26) and (32) 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

Recall that under the equilibrium decision rule (12), we had that the average action was equal to

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

Expressed in terms of basic random variables  $\theta$  and  $\eta$ , we have

$$\bar{a} = \theta + \frac{\alpha\eta}{\alpha + \beta(1-r)}. \tag{35}$$

Thus increases in  $\alpha$  and increases in  $r$  unambiguously reduce the informativeness of the average action as a signal of  $\theta$ . In particular, note that public

information always reduces the informativeness of average actions, even if  $r = 0$ ; but strategic complementarities exacerbate the effect. While we have not formally modelled the social value of information about  $\theta$ , in the paper we have focussed on the importance of the information aggregation role of the economy in private investment decisions and in the forecasting of the central bank. The welfare losses come not from coordination itself, but rather from the externalities generated by the agents playing the beauty contest on those others that rely on prices to be informationally efficient. There is a market failure in which the agents fail to internalize the externalities flowing from uninformative prices.

Some recent debates on the social value of information have focussed on the welfare of the coordinating players themselves actions (rather than their external effect on others learning from their actions). 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

$$\begin{aligned} E[W|\theta] &= -\frac{\alpha^2 E(\eta^2) + \beta^2 (1-r)^2 [E(\varepsilon_i^2)]}{(\alpha + \beta(1-r))^2} \\ &= -\frac{\alpha + \beta(1-r)^2}{(\alpha + \beta(1-r))^2} \end{aligned} \quad (36)$$

Welfare is increasing in the precision of the private signals, as we can see by differentiating (36) with respect to  $\beta$ .

$$\frac{\partial E(W|\theta)}{\partial \beta} = \frac{(1-r)((1+r)\alpha + (1-r)^2\beta)}{(\alpha + \beta(1-r))^3} > 0 \quad (37)$$

However, the derivative of (36) with respect to  $\alpha$  is:

$$\frac{\partial E(W|\theta)}{\partial \alpha} = \frac{\alpha - (2r - 1)(1 - r)\beta}{(\alpha + \beta(1 - r))^3} \quad (38)$$

so that

$$\frac{\partial E(W|\theta)}{\partial \alpha} \geq 0 \quad \text{if and only if} \quad \frac{\beta}{\alpha} \leq \frac{1}{(2r - 1)(1 - r)} \quad (39)$$

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 (36) but rather by

$$-\frac{\alpha + \beta(1 - r^2)}{(\alpha + \beta(1 - r))^2} \quad (40)$$

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. In particular, the welfare effects are closely tied to the fact that better public information allows the agents to eliminate the inefficiencies associated with coordination failure.

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:

$$P_t = \left[ \int_0^1 (p_t^i)^{1-\theta} di \right]^{\frac{1}{1-\theta}} \quad (41)$$

where  $\theta > 1$  is the elasticity of substitution between goods and  $p_t^i$  is the price charged by firm  $i$  at date  $t$ . In effect, the average price is a generalized *harmonic mean* of prices<sup>8</sup>. 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. For other specification of preferences, 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, and any well-grounded conclusion on the overall welfare effect of information must rests

---

<sup>8</sup>More accurately, it is the *power mean* with a negative power. See, for instance, <http://mathworld.wolfram.com/HarmonicMean.html>

on careful motivation of the underlying assumptions.

The sensitivity of Morris and Shin's (2002) original result (as highlighted in the on-line appendix to the paper<sup>9</sup>) 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. Angeletos and Pavan (2005) provide a unified framework for analysing when public information is valuable.

## 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 ( $\alpha$  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 *with* the public signal than without.

Svensson's point can be explained by referring back to welfare as given by (36), but expressed as a function of  $\alpha$ . Let us denote this by  $V(\alpha)$ . Thus,

$$V(\alpha) = -\frac{\alpha + \beta(1-r)^2}{(\alpha + \beta(1-r))^2} \quad (42)$$

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

$$V(0) = -\frac{1}{\beta} \quad (43)$$

---

<sup>9</sup>[http://www.e-aer.org/data/dec02\\_app\\_morris.pdf](http://www.e-aer.org/data/dec02_app_morris.pdf)

There is a hurdle rate  $\bar{\alpha}$  for the precision of the public signal such that welfare *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

$$\bar{\alpha} = \beta(2r - 1) \tag{44}$$

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 *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 *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 influ-

encing 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.

We can gain a glimpse into the difficulties faced by a central bank when it has poor information on the current state of the economy from the Bank of England's experience in 2005. At its August 2005 meeting, the Monetary Policy Committee voted by a majority of five to four to lower the policy rate. The minutes of the meeting<sup>10</sup> represent the views of the members who voted against the cut as follows.

“For these members [who voted against the rate cut], there appeared to be little risk in waiting for further data. Given the difficulty in explaining a reversal of a decision soon after a turning point, should that prove necessary in the light of future data, it was advisable to accumulate a little more evidence than usual before changing interest rates.”

The uncertainty about the current state of the economy clearly played on the minds of all members. The uncertainty as to where the economy actually was at the time is also a prominent theme in the video webcast<sup>11</sup> of the press conference following the publication of the August 2005 *Inflation Report*.

To the extent that uncertainty about current conditions makes forecasting the future more difficult, another tell-tale sign of a drop in signal values

---

<sup>10</sup> <http://www.bankofengland.co.uk/publications/minutes/mpc/pdf/2005/index.htm>

<sup>11</sup> Available from the Bank of England website, <http://www.bankofengland.co.uk>

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 we have seen that 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.

There is some recent evidence of the deterioration of the forecasting accuracy of central banks and their private sector counterparts. The evidence is documented in Schuh (2001) and Campbell (2004) for private sector forecasters and Goodhart (2004) and Tulip (2005) for the Bank of England and Federal Reserve, respectively.

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<sup>12</sup>, the forecast *errors* have not. The fact that policy responses

---

<sup>12</sup>as has been documented by McConnell and Perez-Quiros (2000), Kim and Nelson (1999) and Blanchard and Simon (2001).

are endogenous, and that output fluctuations have moderated all make forecasting more difficult. Nevertheless, it is notable from Tulip (2005) that the performance of longer term forecasts for output (up to eight quarters) has not been encouraging. 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). Goodhart (2004) reports findings for the Bank of England's forecast performance, and reports a similar lack of predictive power for longer term forecasts, but Goodhart points out that when the central bank acts on the forecasts themselves, the lack of correlation between the initial forecast and the final outturn should be expected. Campbell (2004) reports results from private sector forecasts, and finds that short-term forecasts of the Survey of Professional Forecasters have a negative *R*-squared over the period 1984-2003, echoing Tulip's result for the Federal Reserve.

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<sup>13</sup>

[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. [T]he 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.<sup>14</sup> Central bank transparency presents some of the most interesting and challenging policy issues of our time.

---

<sup>13</sup>Available from [www.federalreserve.gov/fomc/transcripts/1992/augmeet.pdf](http://www.federalreserve.gov/fomc/transcripts/1992/augmeet.pdf). We are grateful to Anil Kashyap for drawing our attention to these transcripts.

<sup>14</sup>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.

## References

Adam, Klaus (2003): “Optimal monetary policy with imperfect common knowledge”, working paper, Frankfurt University.

Allen, Franklin, Stephen Morris and Hyun Song Shin (2002): “Beauty contests and iterated expectations in asset markets”, forthcoming in the *Review of Financial Studies*,  
<http://nuff.ox.ac.uk/users/shin/working.htm>

Amato, J. and H. S. Shin (2004) “Imperfect Common Knowledge and the Information Value of Prices” forthcoming in *Economic Theory*, symposium issue on monetary policy  
<http://www.nuff.ox.ac.uk/users/Shin/working.htm>

Angeletos, G. and A. Pavan (2004) “Transparency of Information and Coordination in Economies with Investment Complementarities” working paper, MIT and Northwestern University.

Angeletos, G. and A. Pavan (2005) “Efficiency and Welfare in Economies with Incomplete Information” working paper, MIT and Northwestern University.

Bacchetta, Philippe and Eric van Wincoop (2002): “Can information heterogeneity explain the exchange rate determination puzzle?”, unpublished paper, Studienzentrums Gerzensee.

Bacchetta, Philippe and Eric van Wincoop (2004) “Higher Order Expectations in Asset Pricing”, unpublished paper, Studienzentrums Gerzensee.

Ball, L. and N. Sheridan (2003) “Does Inflation Targeting Make a Difference?” in B. S. Bernanke and M. Woodford eds *The Inflation Targeting Debate*, University of Chicago Press, Chicago.

Bank of England (2005) *Inflation Report*, August 2005,  
<http://www.bankofengland.co.uk/publications/inflationreport/2005.htm>

Bean, Charles (2003) “Asset Prices, Financial Imbalances and Monetary Policy: Are Inflation Targets Enough?” paper presented at the Reserve Bank of Australia annual conference,  
<http://www.rba.gov.au/PublicationsAndResearch/Conferences/2003/>

Bernanke, B. (2004a) “Central Bank Talk and Monetary Policy” Remarks at the Japan Society Corporate Luncheon, New York, October 7, 2004  
[www.federalreserve.gov/boarddocs/speeches/2004/200410072/default.htm](http://www.federalreserve.gov/boarddocs/speeches/2004/200410072/default.htm)

- Bernanke, B. (2004b) "The Logic of Monetary Policy" Remarks before the National Economists Club, December 2, 2004  
[www.federalreserve.gov/boarddocs/speeches/2004/20041202/default.htm](http://www.federalreserve.gov/boarddocs/speeches/2004/20041202/default.htm)
- Bernanke, B., T. Laubach, F. Mishkin and A. Posen (1999) *Inflation Targeting: Lessons from the International Experience*, Princeton University Press, Princeton.
- Bernanke, B. and F. Mishkin (1997) "Inflation Targeting: A New Framework for Monetary Policy?" *Journal of Economic Perspectives*, 11, 97-116.
- Blanchard, O. and J. Simon (2001) "The Long and Large Decline in U.S. Output Volatility" *Brookings Papers on Economic Activity*, 1, 135-64.
- Blinder, Alan *Central Banking in Theory and Practice*, MIT Press, Cambridge, 1998.
- Brayton, L., J. Roberts and J. Williams (1999) "What's Happened to the Phillips Curve?" Federal Reserve Board discussion paper,  
<http://www.federalreserve.gov/pubs/feds/1999/199949/199949pap.pdf>
- Campbell, S. D. (2004) "Macroeconomic Volatility, Predictability and Uncertainty in the Great Moderation: Evidence from the Survey of Professional Forecasters" Finance and Economics Discussion Series 2004-52, Federal Reserve Board, Washington DC.
- Chen, Q., I. Goldstein and W. Jiang (2005) "Price Informativeness and Investment Sensitivity to Stock Price" working paper, Wharton School and Duke University.
- Cornell, B. (1983) "Money Supply Announcements Puzzles: Review and Interpretation" *American Economic Review*, 73, 644-57.
- Fisher, I. (1930) *The Theory of Interest*, Kelley and Millman, New York, re-issued, 1954.
- Fleming, Michael J. and Eli M. Remolona (1999) "Price Formation and Liquidity in the U.S. Treasury Market: The Response to Public Information," *Journal of Finance* 54, 1901-15.
- Gali, J. and M. Gertler (1999) "Inflation Dynamics: A Structural Econometric Analysis" *Journal of Monetary Economics*, 44, 195-222.
- Geraats, P. (2002) "Central Bank Transparency" *Economic Journal* 112, F532-F565.

- Goodhart, C. A. E. (2004) “The Interaction between the Bank of England’s Forecasts and Policy, and the Outturn” working paper, Financial Markets Group, London School of Economics.
- Grossman, S. (1976). “On the Efficiency of Competitive Stock Markets where Traders Have Diverse Information,” *Journal of Finance* 31, 573-585.
- Gurkaynak, R., A. Levin and E. Swanson (2005) “Inflation Targeting and the Anchoring of Long-Run Inflation Expectations: International Evidence from Daily Bond Yield Data” paper at the Riksbank workshop on Inflation targeting, June 2005, <http://www.riksbank.com/templates/Page.aspx?id=15814>
- Gurkaynak, R., B. Sack and E. Swanson (2005) “The sensitivity of long-term interest rates to economic news: evidence and implications for macroeconomic models” *American Economic Review*, 425 - 433.
- Hayek, F. (1945) “The Use of Knowledge in Society” *American Economic Review*, 35, 519-530.
- Hellwig, C. (2002): “Public announcements, adjustment delays and the business cycle”, unpublished paper, UCLA.
- Hellwig, C. (2004) “Heterogeneous Information and the Benefits of Transparency” working paper, UCLA.
- Kasa, Kenneth (2000): “Forecasting the forecasts of others in the frequency domain”, *Review of Economic Dynamics*, 3, pp 726-756.
- Keynes, J. *The General Theory of Employment, Interest, and Money*, MacMillan, London, 1936
- Kim, C. J. and C. Nelson (1999) “Has the U. S. Economy Become More Stable? A Bayesian Approach Based on a Markov-Switching Model of the Business Cycle” *Review of Economics and Statistics*, 81, 608-16.
- Kohn, Donald (2005) “Central Bank Communication” Remarks at the annual meeting of the American Economic Association, Philadelphia, January 9, 2005  
<http://www.federalreserve.gov/boarddocs/speeches/2005/20050109/default.htm>
- Kuttner, K. (2004) “The Role of Policy Rules in Inflation Targeting” working paper, Oberlin College.
- Lange, O (1936) “On the Economic Theory of Socialism: Part One” *Review of Economic Studies*, 4, 53-71.

- Lange, O (1937) "On the Economic Theory of Socialism: Part Two" *Review of Economic Studies*, 4, 123-142.
- Leiderman, L. and L. Svensson (1995) *Inflation Targets*, Centre for Economic Policy Research, London.
- Levin, A., F. Natalucci and J. Piger (2004) "Explicit Inflation Objectives and Macroeconomic Outcomes" working paper 383, European Central Bank, <http://ssrn.com/abstract=569630>.
- Lucas, Robert E. (1972) "Expectations and the Neutrality of Money" *Journal of Economic Theory*, 4, 103-24.
- Lucas, Robert E. (1973) "Some International Evidence on Output-Inflation Tradeoffs" *American Economic Review*, 63, 326-34.
- Mankiw, G., R. Reis and J. Wolfers (2004) "Disagreement about Inflation Expectations" *NBER Macroeconomics Annual 2003*, Cambridge, MIT Press, 2004.
- Mackowiak, B. and M. Wiederholt (2005) "Optimal Sticky Prices under Rational Inattention" working paper, Humboldt University, Berlin.
- McConnell, M. and G. Perez-Quiros (2000) "Output Fluctuations in the United States: What Has Changed since the Early 1980s?" *American Economic Review*, 90, 1464-76.
- Meade, E. E. and D. Stasavage (2005) "Publicity of Debate and the Incentives to Dissent: Evidence from the US Federal Reserve" working paper, American University and LSE.
- Morris, S. and H. S. Shin (2002) "The Social Value of Public Information" *American Economic Review*, 92, 1521-1534.
- Morris, S., H. S. Shin and H. Tong (2005) "Response to 'The Social Value of Public Information: Morris and Shin (2002) is Actually Pro Transparency, Not Con'" forthcoming in *American Economic Review*.
- Pearlman, J. G. and T. J. Sargent (2005) "Knowing the Forecasts of Others" *Review of Economic Dynamics*, 8, 480-497
- Phelps, E. "Introduction" in E. Phelps et al. (eds) *Microeconomic Foundations of Employment and Information Theory*, 1970 pp 1- 23, Norton, New York.

- Phelps, E. “The Trouble with “Rational Expectations” and the Problem of Inflation Stabilization” in R. Frydman and E. Phelps (eds) *Individual Forecasting and Aggregate Outcomes*, Cambridge University Press, New York, 1983.
- Perry, G. L. (2005) “Gauging Employment: Is the Professional Wisdom Wrong?” *Brookings Papers on Economic Activity*, this issue.
- Polk, C. and P. Sapienza (2002) “The Real Effects of Investor Sentiment” working paper, Northwestern University.
- Radner, R. (1979) “Rational Expectations Equilibrium: Generic Existence and the Information Revealed by Prices” *Econometrica*, 47, 655-678
- Rogoff, K. (2003) “Globalization and Global Disinflation” paper presented at the Federal Reserve Bank of Kansas conference in Jackson Hole, 2003.
- Roley, V. (1983) “The Response of Short-Term Interest Rates to Weekly Money Announcements” *Journal of Money, Credit and Banking*, 15, 344-354.
- Roley, V. and C. Walsh (1985) “Monetary Policy Regimes, Expected Inflation and the Response of Interest Rates to Money Announcements” *Quarterly Journal of Economics*, 100, 1011-1039.
- Romer, Christina and David Romer (2000) “Federal Reserve Private Information and the Behavior of Interest Rates” *American Economic Review*, 90, 429-457.
- Sargent, Thomas (1991) “Equilibrium with Signal Extraction from Endogenous Variables” *Journal of Economic Dynamics and Control*, 15, pp 245-273.
- Schuh, S. (2001) “An Evaluation of Recent Macroeconomic Forecast Errors” *New England Economic Review*, Federal Reserve Bank of Boston, Jan-Feb, 35-56.
- Sims, C. (2002) “The Role of Models and Probabilities in the Monetary Policy Process” *Brookings Papers on Economic Activity*, 2, 1-62.
- Sims, C. (2003) “Implications of Rational Inattention” *Journal of Monetary Economics*, 50, 665-690.
- Svensson, L. (1999) “Inflation Targeting as a Monetary Policy Rule” *Journal of Monetary Economics*, 43, 607-654.

Svensson, L. (2004) “Challenges for Monetary Policy” paper for the Bellagio Group Meeting at the National Bank of Belgium, January 2004, [www.princeton.edu/~svensson](http://www.princeton.edu/~svensson).

Svensson, L. (2005) “The Social Value of Public Information: Morris and Shin (2002) is Actually Pro Transparency, Not Con” forthcoming in *American Economic Review*.

Svensson, L. and M. Woodford (2005) “Implementing Optimal Policy through Inflation-Forecast Targeting” in B. S. Bernanke and M. Woodford, eds, *The Inflation Targeting Debate*, University of Chicago Press, Chicago.

Townsend, Robert M (1983): “Forecasting the forecasts of others”, *Journal of Political Economy*, 91, pp 546-588.

Tulip, Peter (2005) “Has Output Become More Predictable? Changes in Greenbook Forecast Accuracy” Finance and Economics Discussion Series, Federal Reserve Board, Washington DC, forthcoming.

Ui, T. (2003) “A Note on the Lucas Model: Iterated Expectations and the Neutrality of Money” working paper, Yokohama National University <http://www2.igss.ynu.ac.jp/~oui/>

Woodford, Michael (2003a): “Imperfect common knowledge and the effects of monetary policy” in P Aghion, R Frydman, J Stiglitz and M Woodford (eds) *Knowledge, Information and Expectations in Modern Macroeconomics: In Honor of Edmund S Phelps*, Princeton University Press, Princeton, pp 25-58.

Woodford, Michael (2003b): *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press, Princeton.

Woodford, Michael (2005) “Central Bank Communication and Policy Effectiveness” paper presented at Federal Reserve Bank of Kansas City Economic Symposium at Jackson Hole, August 2005.