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Listening Without Understanding

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Central bank transparency, financial markets and the crowding out of private information

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Abstract
The trend of monetary policy transparency has recently extended itself to the practice of providing guidance on the likely direction of policy rates. There is a risk that communicating the central bank's own outlook for interest rates actually undermines the financial markets' ability to predict monetary policy. This paper analyzes this risk using the Diamond (1985) model of a financial market, which includes both costly private information acquisition and a costless public signal. We demonstrate that a sufficiently precise signal from the central bank can result in a deterioration of the financial market's ability to predict monetary policy through the crowding out of private information acquisition. Central banks could alleviate this risk with a policy of limiting the guidance offered to the financial market in order to leave sufficient scope for private information acquisition.

Keywords: Interest Rates, Monetary Policy, Information and Financial Market Efficiency, Communication, Transparency, Information Acquisition

JEL classification: E43, E52, G14

"The danger that I see is that the market becomes lazy. And, in a way, if it is spoiled to the point that it is told everything in advance, it relies not on its own analysis, but on the analysis of the central bank."

Tommaso Padoa-Schioppa[1]

1 Introduction

Central banks have recently experimented with providing guidance on the future path of policy interest rates. So far, this appears to have made it easier for the financial markets to predict monetary policy, suggesting it enhances their functioning. Such a conclusion could be premature, however. There is a risk that financial market participants will become overly reliant on central bank interest rate projections. Financial markets could neglect other potentially important sources of information, thereby actually undermining the ability of the financial markets to predict interest rates.

How could financial markets overweigh projections from the central bank? There are at least three ways. First, signals from the central bank might act as a focal point for the coordination of expectations. Second, if all market participants incorporate the same public signal into their expectations their forecasts will become correlated and this will introduce an error into the information aggregated into the market price. Third, a costless signal from the central bank can crowd out costly information gathering by financial market participants. The first possibility is explored by Morris and Shin (2002) in a general setting. The contribution of our paper is that it looks at the second and third ways in a model that explicitly represents a financial market and has no co-ordination effects.

This paper uses the Diamond (1985) model as a starting point to examine the crowding out of private information by a central bank signal. In Diamond's market traders deal in an asset that delivers an uncertain pay-out based on central bank policy rates. The reason that, unlike Morris and Shin (2002), there are no co-ordination effects in this model is because the pay-out is not dependent on the expectations of other financial market participants. Traders receive a costless public signal from the central bank about the likely interest rate decision. They can also buy a private signal which provides an independent

[1] Former ECB Executive Council member, in an interview with the Wall Street Journal Europe by Sims (2004)

source of information on the final pay-out. Furthermore, the Diamond model takes into account that the price itself also provides costless information because it reflects the aggregate of all private information.

We define a measurement for the ability of the market to predict interest rates, which we call the pricing error. This is the variance of the difference between the price and the final pay-out. We determine what precision of the public signal minimizes the pricing error.

Our conclusion from this analysis is that it is not always better for a central bank to communicate with the maximum precision that it can possibly attain. There are two cases in which full transparency is optimal. First, if the central bank can provide only an imprecise signal and, second, if it can provide a very precise signal. In the first case an imprecise signal would not crowd out private information to the extent that it would harm market performance. In the second case, the central bank could provide such a precise signal that it would be able to compensate for the information that has been crowded out. Barring these two cases it would actually be optimal from the perspective of the performance of the financial market for the central bank to offer a less precise signal than it is actually able to. Then it would leave sufficient incentive for the market to acquire its own information and enrich the total information available to the market and limit the pricing error.

This paper proceeds as follows. The next section reviews relevant developments of central bank communication and the related literature. Section 3 describes the setup of the Diamond model and discusses the implications of Diamond's own analysis for central bank communication policy. In Section 4 we perform our own analysis in order to examine the consequences of increasing the precision of the public signal. We begin by tracking the information available to traders as the precision of the public signal increases. Then we examine how the ability of the market to anticipate monetary policy is affected by changes in the precision of the public signal. After examining the implications for central bank communication policy we summarize our conlcusions in Section 5.

2 Central bank communication and financial markets

We are concerned specifically with how central bank communication on the likely direction of interest rates impacts the ability of the financial markets to predict monetary policy. Providing such "guidance" on the direction of interest rates is the latest area of monetary policy on which central banks have chosen to be more transparent. This section first offers a brief overview of the generally positive experience central banks have had so far with earlier types of transparency such as stating policy objectives and releasing their economic forecasts. We then describe how the recent policy of some central banks to provide indications about the likely direction of interest rates has worked in practice. This appears to have helped financial markets to predict policy, but there are some reasons to question whether this result will hold generally. We review other literature skeptical of central bank transparency and then briefly introduce the analysis presented in the rest of this paper.

2.1 Monetary policy increasingly transparent

A generation ago central banking was a highly secretive business. For example, the Federal Reserve was sued in 1975 under the Freedom of Information Act because it did not reveal its target for supply in the money market. As Goodfriend (1986) documents, the Fed defended itself effectively in part by saying that keeping its targets secret allowed it to smooth interest rates.

Over the last twenty years, however, central banks have become increasingly open institutions. They now take great pains to communicate a variety of information to all economic agents, ranging from financial market participants to consumers. Transparency has so far come in various types such as the explanation of past policy, insight into the central bank's objectives and even macro-economic forecasts.

Current Fed chairman Ben Bernanke (2005) praised this development during his nomination hearings, stating that "A more transparent policy process increases democratic accountability, promotes constructive dialogue between policy makers and informed outsiders, reduces uncertainty in financial markets, and helps to anchor the public's expectations of long-run inflation . . ."

2.2 Transparency has, so far, contributed to predictable policy

The increasing openness of policy makers has been accompanied by a burgeoning academic literature. Much of it has been concerned with the macro-economic effects of central bank transparency rather than the financial market implications that we are interested in here. This research has generally supported the notion that transparency contributes to achieving the goal of price stability. Some examples are Eijffinger, Hoeberichts and Schaling (2000), Demertzis and Hallett (2002), Chortareas, Stasavage and Sterne (2003), Geraats (2004), Orphanides and Williams (2005) and van der Cruijsen and Demertzis (2007).

Compared to the macro-economic research there has been little theoretical work on the financial market impact of transparency. Most of what has been done is a reaction to the old secretiveness of the Fed discussed at the beginning of the section. These papers use models of the money market where the Fed's money supply target is unknown. Conclusions differ. Tabellini (1987) demonstrates that secretiveness increases interest rate volatility, while Cosimano and van Huyck (1993) find the opposite. Dotsey (1987) shows that the Fed's secretiveness about the current money supply target makes it more difficult for banks to forecast future interest rates while Rudin (1988) adjusts Dotsey's model to demonstrate the opposite.

The debate has largely been settled empirically. Announcing short-term policy targets and the other types of transparency implemented so far have allowed financial markets to better predict policy. Tomljanovich (2004), for example, finds this to be the case for seven industrialized countries. Swanson (2004), on the basis of option prices, also concludes that the consensus on the Fed Funds outlook has grown.

Since such research, however, central banks have extended their policy of transparency to providing information on the interest rate outlook. We address whether this type of transparency will, like previous steps, further enhance the predictability of monetary policy.

2.3 Central bank "guidance" on the interest rate outlook

Broadly speaking, each positive experience with central bank transparency has encouraged further steps. Central banks started by simply revealing their target interest rate. Then they moved onto explaining their actions and being more explicit about their objectives. After this, central banks started to reveal their macro-economic forecasts.

The latest step in the direction of greater transparency has been for central banks to provide an outlook for interest rates. This policy has clear theoretical underpinnings. Woodford (2005) accompanied by Svensson and Tetlow (2005) argue that the only consistent and complete way for a central bank to release forecasts about the economy is to communicate an accompanying path for official interest rates. Although this raises the practical problems of how a central bank should define and communicate its own reaction function, it is precisely because of this that it forces maximum transparency.

The central banks of New Zealand and Norway have implemented such a policy by publishing quantitative interest rate projections. More prominently the Fed and the ECB have experimented with giving the financial markets qualitative guidance about the likely path of interest rates.

Starting in May 2004 the Fed incorporated the text ". . . the Committee believes that policy accommodation can be removed at a pace that is likely to be measured" in its post-meeting press statement. Similar "measured language", as it became known in the financial markets, was maintained until November 2005. There was some discussion within the Fed's policy setting body, the Federal Open Market Committee (FOMC), about the appropriateness of the "measured language". The May 2004 minutes reveal that "A number of policymakers were concerned that such an assertion could unduly constrain future adjustments to the stance of policy."

The ECB also offered the financial markets some guidance concerning the likely path of the series of rate hikes undertaken by the central bank starting in December 2005. Trichet used code words to indicate the likelihood of rate hikes in the upcoming three scheduled meetings of the ECB Governing Council. The financial markets came to understand that "monitor closely" meant that a rate hike was likely three meetings later. "Monitor very closely" meant that a rate hike was likely two meetings later. Finally, multiple uses of the word "vigilance" implied a rate hike at the next meeting. Furthermore, President Trichet (2006, 2007) endorsed the market's expectations of future interest rate hikes that were priced into the forward curve.

The perception of the Fed and ECB is that the policy of guiding the financial markets to price in a certain path of interest rates has contributed to the predictability of monetary policy. The Fed noted in its July 2005 Monetary Policy Report to the Congress that the "policy actions had all been widely anticipated by investors for some time before each meeting." The ECB mentions in its December 2006 Monthly Bulletin that implied volatility in the money market had reached record lows thanks to the low degree of uncertainty on the future path of interest rates.

2.4 Central banks like financial markets that can predict policy

Central banks are concerned about the predictability of monetary policy. Monetary policy publications such as the ones mentioned above or the minutes of the FOMC meetings routinely examine how well the markets have priced in policy moves. Why should central banks care about predictability and why is this important?

There are at least three interrelated reasons why central banks are happy with financial markets that can anticipate their policies. First, it is a reflection of the overall transparency of policy, which should be sufficient to allow economic agents to understand monetary policy and its relationship with the economy. Second, the more efficiently financial markets can price in the future, the better they function as a risk management tool. Third, avoiding unanticipated policy changes could prevent financial market volatility. While the first reason implies that predictability can be seen as an indicator of overall transparency, the second and third suggest that transparency can promote the functioning of the financial markets.

Regarding the first reason, central bank transparency should contribute to the understanding of all economic agents of how monetary policy works and how it relates to the economy. The predictability of monetary policy by the financial markets is used as an indicator of overall transparency because the expectations of financial markets can be measured directly. Ehrmann and Fratzscher (2005), for example, use the predictability of central bank policy as a means to compare the effectiveness of communication styles of the monetary policy committees of the Fed, ECB and Bank of England.

Central bankers like to see financial markets predict monetary policy not just because it indicates that monetary policy is transparent. The second reason is that they are concerned with the functioning of the financial markets themselves. Financial markets by their very nature are concerned with efficiently pricing in expectations and risks. This is something that is central to their function of allocating resources and managing risks[2]. Transparent monetary policy can contribute to well functioning financial markets. Gramlich (2003) points out that transparency is "valuable from a market efficiency standpoint." He jokes that "when new data come out, I can pick up the newspaper and learn what I think of these new data, often with pretty good accuracy."

The third reason that predictability is nice is because it avoids volatility in financial markets. The apparent aversion of central bankers to interest rate volatility is a point of discussion in the literature on interest rate smoothing. Bamport (2003) for example states that although there is some evidence that members of the Bank of England's Monetary Policy Committee dislike interest rate market volatility, he sees no evidence that this influences their interest rate decisions. Bernanke (1988) gives a reason why this dislike does not necessarily have to express itself in the setting of interest rates. He says that although undue stress in the bond market is to be avoided, the best way to do this is not through gradual monetary policy but through communications designed to improve policy predictability. Central bankers feel that one role for monetary policy transparency is to help markets predict policy better and thereby reduce volatility in the financial markets. The central question for this paper is whether providing guidance on the likely direction of interest rates actually serves this purpose.

[2] Morris and Shin (2002) offer a more in-depth discussion of the importance of the allocative role of financial markets and give some illustrations.

2.5 Financial markets can follow guidance without understanding policy

What all three aspects of predictability have in common is the idea that the predictability of monetary policy and the understanding of policy by the financial markets are intimately related. This is not necessarily the case, however. Precisely when a central bank offers guidance on the direction of interest rates is it possible for financial markets to predict policy simply by adopting the central bank's forecasts. This requires no understanding of how monetary policy works or how it is related to the economy.

King (2000) states "A transparent monetary policy reaction function means that the news should be in developments of the economy not in the announcements of decisions by the central bank." Similar reasoning could apply to interest rate projections by the central bank. It is the understanding of how monetary policy works and how it relates to expected changes in the economy that should make future policy changes predictable, not the statements on future policy moves by the central bank itself.

In Section 4 we shall show that it is even possible that giving guidance on the direction of interest rates can act to reduce the understanding of monetary policy. This is because it can lead to less information about the direction of policy being aggregated into the market.

2.6 Financial markets can overweigh central bank communication

When financial markets follow guidance without understanding policy, there could be a danger that they will come to rely on interest rate forecasts from the central bank. Markets might, as former ECB council member Padoa-Schioppa put it in the quote at the start of this paper, become "lazy." If this happens the predictability of monetary policy would be dependent on the central bank's ability to forecast its own interest rate path. If the central bank were to get things wrong this could undermine the functioning of the financial markets and increase volatility.

Certainly if the central bank were better at predicting its own interest rate path than the financial market as a whole, then relying on its forecasts would not be a problem. Nevertheless, even though central bankers have a unique insight into their own preferences and objectives, it is not obvious that they are better at forecasting interest rates. There is some evidence, such as that provided by Romer and Romer (2000) that the Fed is better at economic forecasting than private sector economists. Even if this could be translated directly to interest rate forecasts it does not necessarily mean that central banks have superior forecasting ability to the financial market as a whole. Financial markets are able to aggregate diffuse sources of information into one price, a line of thinking famously espoused by Hayek (1945). Recent research on prediction markets, such as those used to trade on the outcome of elections or anticipate economic data releases, lends support to the idea that markets have superior forecasting ability. Wolfers and Zitzewitz (2006) review the literature on prediction markets and find that these markets tend to outperform polls and experts. The Diamond (1985) model that we employ is an extension of a model by Hellwig (1980) which was explicitly designed to capture the way that markets aggregate diverse sources of information.

Should central banks not have a superior ability to forecast interest rates then it is not obvious why financial market participants should rely too much on their forecasts. After all, rational agents should optimally combine the forecasts from the central bank with other information based on the precision of the information.

There are, nevertheless, reasons to believe that providing costless public information about the direction of interest rates could lead even rational financial markets participants to overweigh this information relative to costly private information. As Kohn (2005) reflects, ". . . the risks of herding, of overreaction, of too little scope for private assessments of economic developments to show through, would seem to be high for central bank talk about policy interest rates."

There are at least three ways public information can detract from private information. First, the public signal could act as a coordination focal point for private expectations. Second, financial market participants will individually weigh the public signal into their expectations and thus allot less relative weight to their private signal. Although on an individual level this is rational, when aggregated into the price the public signal creates a common error, while the many independent private errors cancel and enhance the price. Third, providing a costless public signal could crowd out costly private information acquisition.

The first argument, i.e. public information can act as a focal point, is explored by Morris and Shin (2002). Their work is probably the most prominent and well publicized critique of central bank transparency. In their view public information can lead to the under-representation of private information when pay-offs are dependent on second order expectations. This is the case when predicting the actions of the other agents influences pay-offs, such as in the Lucas Island Model that Morris and Shin use to illustrate their point. Under these circumstances agents assign extra weight to information they know all other agents receive. The public signal acts as a "rallying point" to coordinate expectations. If this signal were incorrect it could coordinate expectations away from the underlying fundamentals.

The Morris and Shin (2002) model is quite general. It does not explicitly model a financial market. It can be conceptually applied to a financial market, however, as Morris and Shin (2005) show. Both papers invoke the "beauty contest" comparison used by Keynes (1936) to describe the equity market.

Svensson (2005) argues that it is unlikely that public information is so inaccurate that it would lead to undesirable outcomes. He shows in the Morris and Shin model that equal precision for the public and private signals implies higher welfare with the public signal than without.

Demertzis and Hoeberichts (2005) extend the Morris and Shin model to include costs for both private and public information. The behavior of both the central bank and the economic agents are modeled explicitly. Demertzis and Hoeberichts thus model a game between two players who both have an incentive to free-ride off of the information acquisition of the other. They show that the precision of the private signal is decreasing in the precision of the public signal. Our paper also produces this result, but then in a different setting where financial markets are modeled explicitly and there are no effects due to second-order expectations.

The ideas of Morris and Shin are given some empirical support by Chirinko and Curran (2005). They examine the volatility in the 30-year U.S. Treasury bond futures in relation to speeches, Congressional testimonies and FOMC meetings released by former Fed Chairman Alan Greenspan. They conclude that the presence of volatility effects prior to the release suggest that apart from transferring important information these communications could also act as a signal that coordinates market prices.

The other two reasons that a costless public signal might be detrimental to the predictability of monetary policy are the role of common errors and the crowding out of private information acquisition. This paper evaluates a model where both of these effects play a role.

The Diamond (1985) model we employ is a variant of the so-called "rational expectations" models used in the finance and accounting literature to study the reaction of equity markets to public disclosures by listed firms. These models were designed to tackle a problem similar in nature to that presented by the impact of central bank disclosures on financial markets. They are explicitly designed to represent financial markets. The most important aspect of this is that they allow market participants to condition their expectations not only on private and public signals but also on the price itself. The pay-out in this model is not dependent on the expectations of the agents, so results do not rely on the coordination effects described above.

We extend Diamond (2005) with our own analysis to examine the total amount of information available to the market as the precision of the public signal increases. We also study how increasing the precision of the public signal affects the ability of the market to predict monetary policy. We find that it is indeed possible in the Diamond (1985) model for the public signal to crowd out private information and thereby undermine the ability of the financial market to predict monetary policy.

3 The setup of the Diamond model

3.1 The rational expectations disclosure literature

The Diamond (1985) model we employ here is a variant of a so called "rational expectations" model, which represents an efficient financial market in which traders rationally trade on the basis of available information. The aggregation of information by the financial markets is a key element.

The label "rational expectations" model is not particularly informative, but it is the conventional term used in the literature. Dye (1986) uses the more descriptive term "pure exchange linear rational expectations" model. This better reflects the fact that such a model describes a pure exchange economy in which there is no activity other than the trading of assets. All welfare effects within the model are thus related to the distribution of these assets and the costs of trading them. These models are linear in the sense that traders make linear conjectures about the price function.

The term "rational expectations" refers to the salient feature of these models, namely that they allow traders to condition their beliefs on the price itself. The price reflects the private information of the other traders, something that rational traders would not ignore. This aspect leads to an extra condition for the equilibrium in the market. It is not sufficient for the market to clear, it must also be so that the resulting price does not lead to a revision of expectations by any trader. Only when all expectations are stable at the current price is there a rational expectations equilibrium.

This type of model has been used to study different aspects of financial markets. One of the more common applications is to examine the consequences of public disclosures, which is an important theme in the finance literature because listed companies have increasingly been required to release all kinds of information to the equity markets[3].

Some of the models studying public disclosure employ costly information acquisition. Below we employ the no-frills version of this type of model presented in Diamond (1985) and give a description of its relevant features. More details can be found in Diamond (1985) itself and the papers that Diamond refers to, namely Hellwig (1980), Diamond and Verrecchia (1981) and Verrecchia (1982a).

[3] See Verrecchia (2001) for an overview of the literature on public disclosure

3.2 The Diamond model without public disclosure

To describe the Diamond (1985) model we begin with a version in which there is no public disclosure. As stated above, variants of the rational expectations model, such as Diamond (1985), represent pure exchange economies. There are random amounts of a risky and riskless asset endowed to traders who only observe their own initial endowment and not that of others. Traders exchange assets in the open market and then consume whatever assets they have afterwards. A unit of the riskless asset produces one unit of consumption good with certainty. The pay-out of the risky asset, referred to as the return, is uncertain. Before the traders exchange assets they can purchase a private signal which gives them information about the return of the risky asset.

Traders in this model have constant absolute risk aversion preferences (exponential utility). The level of risk tolerance is the same for all traders and is represented by $r>0$.

The return on the risky asset is represented by $\tilde{u}$, where the tilda is used to indicate that this is a random variable. Traders have knowledge about the nature of $\tilde{u}$. They know that it is normally distributed with mean Y_0 and precision (the inverse of the variance) of $h_0>0$.

The number of traders approaches infinity so that no single trader has the ability to influence the market. Traders are indexed by $t=1,\ldots,T$ where $T\longrightarrow\infty$.

Traders can purchase a private signal about the return of the risky asset at a cost $c>0$. The signal is the random variable $\tilde{y}_t$, which is defined as

$$\tilde{y}_t = \tilde{u} + \varepsilon_t$$

Here ε_t is a noise term with mean 0 and precision $s>0$. This is independent of the other random variables including the error of the private signal of other traders. The fraction of informed traders, i.e. those that purchase this signal, is $0\leq \lambda \leq 1$.

Besides uncertainty about the return of the risky asset there is also uncertainty about the supply of the risky asset. In a rational expectations model information cannot be the only stochastic influence on the market. Otherwise traders would be able to perfectly extract the information from the price, i.e. prices would then become fully revealing. We will return to this topic below.

Trader t is endowed with $\tilde{B}_t$ riskless assets and $\tilde{x}_t$ risky assets. The latter is a normal random variable with variance $T\bullet V>0$ which is independent of the endowments of risky assets of the other traders and all of the informational random variables.

Per capita supply of the risky asset is defined as follows,

$$\tilde{X} = (1/T)\sum_{t=1}^{T}\tilde{x}_t$$

As result $\tilde{X}$ has a normal distribution and a variance of $V>0$. The correlation of $\tilde{x}_t$ with $\tilde{X}$ approaches zero as the number of traders approaches infinity so that the individual endowment provides no information about the per capita supply of risky assets.

To supply some intuition behind the model we describe the decision process of the traders. They receive a random individual endowment of riskless and risky assets. On the basis of whatever information they can gather they decide what part of this endowment to trade with others. They already know the expectation of the return, presumably because they have observed past realisations and have made an average. Some traders will also have purchased private information. Finally, all traders realise that once trading commences they can extract more information from the price. To make sense of the price, however, they must understand how the market works. They thus form a model of how the price is related to the return and supply. Because these are rational traders this model is the best available unbiased estimate of the relationship between these variables.The rational expectations equilibrium occurs when all traders use the same accurate model. Under the assumptions of exponential utility and normally distributed random variables, a linear relationship is an equilibrium.

To recap more formally, the traders form a linear conjecture about the joint probability distribution of the private signal, $\tilde{y}_t$, the per capita supply, $\tilde{X}$, the return of the risky asset, $\tilde{u}$, and the price, $\tilde{P}$. The rational expectations equilibrium is that conjecture that is self-fulfilling.

The linear equilibrium joint distribution that results is shown below and is stated in terms of the fraction of informed traders, λ. Traders must also form a conjecture about λ and in equilibrium this too will be self-fulfilling. After discussing the equation below we will say more about how λ itself results.

$$\tilde{P} = \alpha Y_0 + \beta\tilde{u} - \gamma\tilde{X}$$

where

$$\alpha = \frac{h_0}{h_0 + \lambda s + \frac{(r\lambda s)^2}{V}}$$

$$\beta = \frac{\lambda s + \frac{(r\lambda s)^2}{V}}{h_0 + \lambda s + \frac{(r\lambda s)^2}{V}}$$

$$\gamma = \frac{\frac{1}{r} + \frac{r\lambda s}{V}}{h_0 + \lambda s + \frac{(r\lambda s)^2}{V}}$$

The first two parts are an unbiased estimate of the return of the risky asset. The parameters α and β are weights. Their denominator represents the per capita information, i.e. the average amount of information available per trader[4]. We will label this I.

$$I = h_0 + \lambda s + \frac{(r\lambda s)^2}{V}$$

The first term is the precision of the prior knowledge. The second term is the average precision of the private signal. Informed traders will receive a precision s, while other traders will receive no signal, so on average the precision is λs. The final term is called the informativeness of the price[5]. This is the precision of the information that the traders can distill from the price. Note that if the supply variance, V, were to equal zero then the precision of the information that could be extracted from the price would approach infinity. This is what is meant by prices becoming fully revealing if there is no other source of uncertainty in the model.

The weights α and β represent the share of information provided by the prior knowledge and the information released in the private signal. Note that the private information finds its way to the traders by two routes; first, via the direct route to informed traders; second, it leaks out through the price to all traders. Traders that have already bought their own signal still benefit from the informativeness of the price because the individual signals purchased are independent.

Note also that the the private signal, $\tilde{y}_t$, is not explicetely part of the equilibrium equation. The private information is the sum of the return and an error, $\tilde{y}_t = \tilde{u} + \varepsilon_t$. The errors of the individual traders are independent and there are an infinite number of traders, which results in the influence of the individual errors on the price cancelling out. In the aggregate the private information is a perfect indicator of the price. We discuss the implications of this later on in the paper.

The last term, preceded by γ, reflects the impact of the supply on the price. This effect exists because the traders are risk averse; i.e. they are not infinitely risk accepting, r$<\infty$. You can see this by noting that as risk acceptance approaches infinity, i.e. traders become risk neutral, then γ approaches zero and supply is no longer relevant. The intuition behind this supply effect is that a risk averse trader can only be induced to buy a risky asset by lowering the price.

[4] Note, Diamond (1985) represents α, β and γ differently, which makes this observation less obvious.

[5] Verrecchia (1982a) and Verrecchia (1982b) contains more information on the informativeness of the price and per capita information.

Part of the equilibrium joint distribution is λ, the fraction of traders that purchase information. A trader will decide to buy information based on the impact this information is expected to have on his utility. This not only depends on the extra information itself, but also on what fraction of other traders is informed. Traders thus also need to have a conjecture about λ. Once again, the rational expectations equilibrium results where this fraction is self-fulfilling.

The equilibrium fraction of informed traders, λ, is a product of risk tolerance, r, the cost of the private signal, c, the precision of the private signal, s, and the precision of the return, h_0.

For $0<\lambda<1$ the following equation characterizes λ in equilibrium,

$$\lambda = \frac{\sqrt{V}}{rs}\sqrt{\frac{s}{e^{2c/r}-1} - h_0} \in (0,1)$$

When all traders are informed then λ=1, which happens when

$$e^{2c/r} - 1 \leq \frac{s}{h_0 + \frac{(rs)^2}{V}}$$

When there are no informed traders then λ=0, which occurs under the following condition,

$$e^{2c/r} - 1 \geq \frac{s}{h_0}$$

3.3 The Diamond model with public disclosure

So far we have looked at the equilibrium in the Diamond model without any public disclosure. We do this merely as a step towards the more interesting case in which there is a public signal. Diamond shows that only a few adjustments to the equations for the price, $\tilde{P}$, and the fraction of informed traders, λ, are needed to incorporate a public signal.

Diamond models a public signal that is released before private information acquisition takes place. This signal is defined as,

$$\tilde{Y} = \tilde{u} + \tilde{\zeta}$$

where $\tilde{\zeta}$ is a normal random variable, independent of $\tilde{u}$, with precision $\Delta>0$.

Diamond shows that this public signal simply augments the prior expectation that the traders have about the return, $\tilde{u}$. This can be seen below.

$$\frac{h_0}{h_0+\Delta}Y_0 + \frac{\Delta}{h_0+\Delta}\tilde{Y} = \frac{h_0}{h_0+\Delta}Y_0 + \frac{\Delta}{h_0+\Delta}(\tilde{u}+\tilde{\zeta}).$$

This is simply the weighted average of the earlier unconditional expectation and the public signal that has been released, with their relative precisions acting as weights.

The precision of this improved expected return is simply the sum of the precision of the return, h_0, and the precision of the public signal

$h_0+\Delta$.

The fact that traders adjust their expectations on the basis of the public information means adjusting the equilibrium joint distribution between the price and the other random variables. As shown in Oliver and Verrecchia (1991) and Verrecchia (2001) this results in the following straightforward changes.

$$\tilde{P} = \alpha\left(\frac{h_0}{h_0+\Delta}Y_0 + \frac{\Delta}{h_0+\Delta}(\tilde{u}+\tilde{\zeta})\right) + \beta\tilde{u} - \gamma\tilde{X}$$

where

$$\alpha = \frac{h_0+\Delta}{(h_0+\Delta)+\lambda s+\frac{(r\lambda s)^2}{V}}$$

$$\beta = \frac{\lambda s+\frac{(r\lambda s)^2}{V}}{(h_0+\Delta)+\lambda s+\frac{(r\lambda s)^2}{V}}$$

$$\gamma = \frac{\frac{1}{r}+\frac{r\lambda s}{V}}{(h_0+\Delta)+\lambda s+\frac{(r\lambda s)^2}{V}}$$

Diamond demonstrates that the precision of the public signal has consequences for the fraction of traders that acquire information. This too is a straightforward extension of the conditions and equation for λ presented above.

As long as the public signal is sufficiently imprecise,

$$\Delta \leq \frac{s}{e^{2c/r}-1} - \frac{(rs)^2}{V} - h_0$$

all traders will remain informed, $\lambda=1$.

Once the precision of the public signal, Δ, crosses this threshold, however, crowding out starts and the fraction of informed traders, λ, declines as Δ rises.

$$\lambda = \frac{\sqrt{V}}{rs}\sqrt{\frac{s}{e^{2c/r}-1} - (h_0+\Delta)} \in (0,1)$$

This continues until there are no longer any informed traders, $\lambda=0$, when

$$\Delta \geq \frac{s}{e^{2c/r}-1} - h_0.$$

3.4 Central bank communication and the Diamond model

The results from the model presented above were initially used to analyze the effect of disclosures by listed companies. The idea was to illuminate the effects of regulation requiring increased transparency for listed companies. We can apply the same model to central bank transparency by re-interpreting the results. The relevant questions, however, are somewhat different, which requires us to do some further analysis.

We reinterpret the Diamond model in the following way. The risky asset can be seen as a financial market product with a pay-out that depends on monetary policy. The market that most closely matches this is that for Fed Funds Futures. The pay-out of this derivative depends almost entirely on monetary policy and is given at a fixed point in time when the contract expires. Furthermore, although the volume of trades is public knowledge the supply of futures is uncertain because contracts themselves are only created when supply and demand meet.

One should not limit the conceptual applicability of this market to the Fed Funds Future, however. The return on practically any money market product will be largely determined by expectations of monetary policy and even further down the yield curve the policy rate outlook plays an important role.

The private signal is any costly information or analysis that contributes to the forecasting of the policy rate. This could be anything from buying a copy of the Wall Street Journal to the costs involved in a full scale economic research department. The public signal regards the same policy rate, but is costless information released by the central bank. This should not be seen as a specific announcement. The intention here is not to examine the short term reaction to particular information that is released during a trading day. It would be unrealistic to expect shifts in costly information acquisition to take place on such a timeframe. Here the precision of the public signal is interpreted as representing the general level of information provided by the central bank about its future policy rate through a stream of announcements, speeches and other forms of communication.

Diamond's analysis is targeted at ascertaining the welfare effects of the release of the public signal to the market. The conclusion provided by Diamond is that it is optimal in this pure exchange economy that the public signal is sufficiently precise to crowd out all private information acquisition. A discussed above, Diamond calculates that this happens when the public signal has a precision of

$$\Delta \geq \frac{s}{e^{2c/r} - 1} - h_0.$$

This conclusion is quite intuitive in the context of the model. The only thing that happens in this pure exchange economy is that a fixed set of resources are distributed through the market between the traders or are lost on acquiring private information. The more traders spend on private information the less is available to consume.

It is reasonable to assume that a publicly listed firm can more cheaply provide information in a public signal than the aggregate costs of many traders that individually expend resources on information acquisition. Diamond thus concludes that it is optimal for the firm to release one public signal that crowds out individual acquisition of information. This avoids the duplication of costs implied by the numerous signals acquired by market participants.

Diamond's conclusion only partially applies to central bank transparency. As discussed above, it is not obvious that central banks are better at forecasting future policy than private individuals. Diamond's thinking goes further, however. Even if the central bank had no comparative advantage in the production of information about its own policy then market participants would still benefit if all information acquisition were concentrated at the central bank instead of being duplicated many times in the private sector simply because it would be cheaper. Any resulting degradation in the predictability of the public signal that might result has no negative welfare effects within the model because this is a pure exchange economy where the only issue is the distribution of assets.

The effects of such a policy for a central bank, however, would clearly be broader than just the expenditures by market participants on forecasting policy rates. As discussed in section 2, it is relevant that financial markets can predict policy. Interest rates affect countless decisions by consumers and businesses that have aggregate consequences for output, unemployment and inflation. The costs of malfunctioning or volatile financial markets are likely to dwarf those implied by the aggregate expenditures of economic research and central bank watching done by market participants.

Below we examine the effects of providing guidance on the interest rate outlook to the financial markets' ability to predict monetary policy. We do this by extending Diamond (2005). First we analyze the development of total information as the precision of the central bank signal rises. Then we go on to examine the predictability of interest rates as the precision of the public signal increases.

4 Transparency and the predictability of policy

4.1 Central bank communication and financial market information

Increasing the precision of the public signal can result in the crowding out of private information in the Diamond (1985) model. This only happens, however, if the signal is precise enough. Furthermore, an interesting question is whether this crowding out of private information actually results in a loss of total information for the market. Below we present analysis that shows this is indeed possible.

As stated above, as long as the public signal is sufficiently imprecise, all traders will remain informed, λ=1. Under these conditions the amount of per capita information is described by.

$$I_{\lambda=1} = (h_0 + \Delta) + \lambda s + \frac{(r\lambda s)^2}{V} = (h_0 + \Delta) + s + \frac{(rs)^2}{V}.$$

As long as all traders are informed, λ=1, a higher precision of the public signal will translate directly into a higher per capita information.

This is also true if, all private information acquisition has been eradicated, λ=0. Then all private information, including that communicated through the price, is crowded out. Only the precision of the prior knowledge and the public information remain. As the latter increases so does per capita information.

$$I_{\lambda=0} = (h_0 + \Delta) + \lambda s + \frac{(r\lambda s)^2}{V} = (h_0 + \Delta).$$

The intermediate case, $0 \leq \lambda \leq 1$ is more interesting. Here the fraction of informed traders is

$$\lambda = \frac{\sqrt{V}}{rs}\sqrt{\frac{s}{e^{2c/r} - 1} - (h_0 + \Delta)} \in (0, 1)$$

We substitute this into the equation for I and find the derivative to Δ.

$$\frac{\partial I}{\partial \Delta} = -\frac{\sqrt{V}}{2r\sqrt{\frac{s}{e^{2c/r} - 1} - (h_0 + \Delta)}}$$

As defined above, V>0 and r>0. Also note that due to the condition for λ>0 the statement under the square root is also positive,

$$\frac{s}{e^{2c/r} - 1} - (h_0 + \Delta) > 0.$$

As a result for $1>\lambda>0$ the amount of information is decreasing in the precision of the public signal, Δ. The public signal thus crowds out more information than it replaces. This already suggests that providing guidance on the interest outlook that is too precise undermines the financial markets' ability to predict monetary policy. We will examine this more directly in the next section.

4.2 Communication and the pricing error

To see if an increase in the precision of the public signal can undermine the predictability of the return we need to do some more analysis. A first step is to define an appropriate measure of the ability of the market to predict the monetary policy outcome. The difference between the price, $\tilde{P}$, and the actual return of the risky asset, $\tilde{u}$, is a logical candidate. We use the variance of this as our indicator of the ability of the price to predict the return. We label this indicator the pricing error and symbolize it with Ω. The following equation results

$$\Omega = VAR(\tilde{P} - \tilde{u}) = E\left[\alpha\left(\frac{h_0}{h_0+\Delta}Y_0 + \frac{\Delta}{h_0+\Delta}(\tilde{u}+\tilde{\zeta})\right) + \beta\tilde{u} - \gamma X - \tilde{u}\right]^2$$

where

$$\alpha = \frac{h_0+\Delta}{(h_0+\Delta)+\lambda s+\frac{(r\lambda s)^2}{V}}$$

$$\beta = \frac{\lambda s+\frac{(r\lambda s)^2}{V}}{(h_0+\Delta)+\lambda s+\frac{(r\lambda s)^2}{V}}$$

$$\gamma = \frac{\frac{1}{r}+\frac{r\lambda s}{V}}{(h_0+\Delta)+\lambda s+\frac{(r\lambda s)^2}{V}}$$

We now examine at what precision of the public signal, Δ, the price, $\tilde{P}$, most closely predicts the return of the risky asset, $\tilde{u}$. To do this we find the minimum value of Ω in terms of Δ.

The procedure is relatively conventional and straightforward, but the equations are too long and cumbersome to be included here. Nevertheless, we describe our procedure.

We proceed to find the optima for Ω. In doing so, we need to take into account that the fraction of informed traders is restricted to $0\leq \lambda \leq 1$. Low precision for the public signal, Δ, does not crowd out private information acquisition and still leaves all traders being informed, $\lambda=1$. Intermediate precision sees some fraction of the traders informed $0<\lambda<1$. While high precision means all information acquisition is crowded out, λ=0. The development of Ω needs to be examined for all three parts.

As the precision of the public signal, Δ, rises this does not initially crowd out private information acquisition and as a result λ remains 1. As long as this is the case any additional precision of the public signal translates into a direct improvement in the quality of the price and as such Ω declines as Δ rises. This is intuitive and is easily demonstrated by taking the derivative of $\Omega(\lambda=1)$ and showing that it is always negative.

The development of Ω when all information acquisition has been crowded out is also intuitive and unambiguous. Private information acquisition has already been eradicated, so further increasing the precision of central bank communication results in an improvement of per capita information and $\Omega(\lambda=0)$ always declines as Δ rises. Here too, this is demonstrated by taking the derivative of $\Omega(\lambda=0)$ and showing that it is always negative. Ω approaches 0 as Δ approaches infinity.

As with the examination above of per capita information, the intermediate case, $0<\lambda<1$, is less straightforward and more interesting. We substitute the value for λ for the interval (0,1) into the equation for $\tilde{P}-\tilde{u}$. Then we square this and find the expectation of the resulting equation. This produces the complete form of Ω in terms of only means and variances. Note the following:

$$\mathrm{E}(\tilde{u}) = Y_0$$

$$\mathrm{E}(\tilde{X}) = \mathrm{E}(\tilde{\zeta}) = 0$$

$$\mathrm{E}(\tilde{X}^2) = \mathrm{V}$$

$$\mathrm{E}(\tilde{u}^2) = Y_0^2 + \frac{1}{h_0}$$

$$\mathrm{E}(\tilde{\zeta}^2) = \frac{1}{\Delta}$$

We then find the optima in the usual fashion by setting its first derivative to 0 and examining the sign of the second derivative. This result contains several optima. However, all but one of these fall outside of the range $0<\lambda<1$.

Once the rising precision of the central bank's communication policy starts to crowd out private information acquisition one of two things can happen. The deterioration of private information can be immediately detrimental to the quality of the price as Δ rises. In this case the informativeness of the price suffers as Δ rises until all information acquisition is eliminated. Under this case the minimum Ω for $0<\lambda\leq1$ can be found at the point just before crowding out starts,

$$\Delta = \frac{s}{e^{2c/r}-1} - \frac{(rs)^2}{V} - h_0$$

The other possibility is that Ω initially falls, even as λ declines. In this case there is a minimum in the zone $0<\lambda<1$. This case occurs if the following are true

$$1 > \frac{V}{sr^2}, \frac{1}{e^{2c/r}-1} > \frac{V}{sr^2}$$

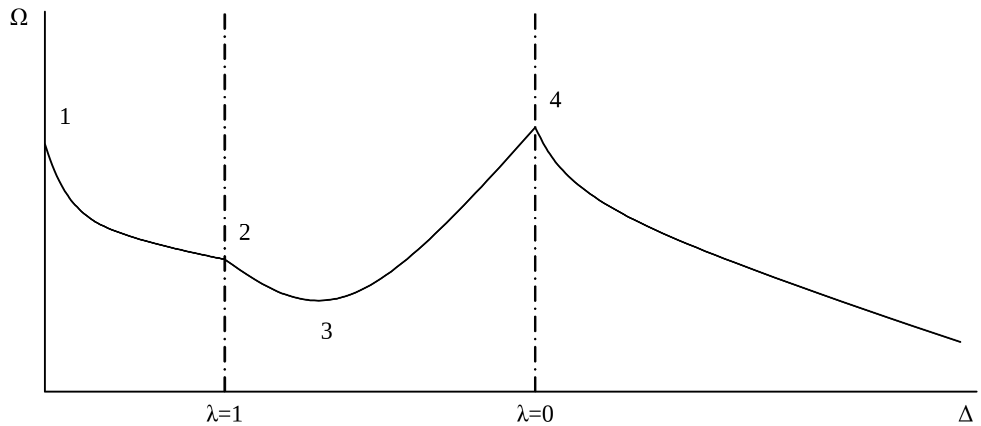
The graphs presented give a sense of how Ω might develop. The two figures are sketches only and cannot capture all the possible variations of the development of the pricing error, Ω. For example, although point 2 and 3 (if it exists) are always lower than both points 1 and 4, the relative position of 1 and 4 can differ from what has been represented here. The representations chosen also assume that prior information, h_0, is not so precise that crowding out of private information hasn't already taken place

$$h_0 < \frac{s}{e^{2c/r}-1} - \frac{(rs)^2}{V}.$$

The table below summarizes the relevant regions and points labeled in the graph.

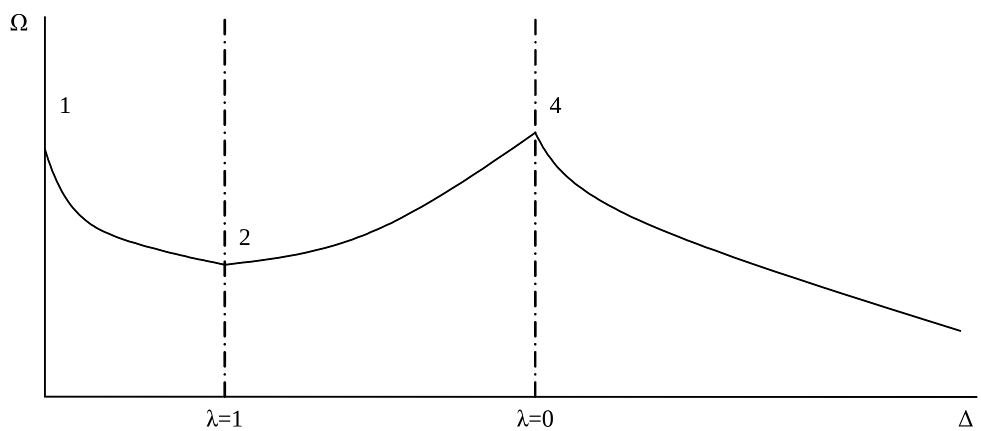
if $1 > \dfrac{V}{sr^2}, \dfrac{1}{e^{2c/r}-1} > \dfrac{V}{sr^2}, h_0 < \dfrac{s}{e^{2c/r}-1} - \dfrac{(rs)^2}{V}$

Figure 1: Local minimum for 0<λ<1



otherwise

Figure 2: No local minimum for 0<λ<1



Point#	Nature for pricing error Ω	Fraction of informed traders (λ)	Precision of pulic signal (Δ)
1	Global maximum if $\Omega_{\Delta=0} > \Omega_{\lambda=0}$	$\lambda = 1$	$\Delta = 0$
2	Local minimum if $1 \leq \dfrac{V}{sr^2}$	$\lambda = 1$	$\Delta = \dfrac{s}{e^{2c/r}-1} - \dfrac{(rs)^2}{V} - h_0$
3	Local minimum if $1 > \dfrac{V}{sr^2}$ and $\dfrac{1}{e^{2c/r}-1} > \dfrac{V}{sr^2}$	$\lambda = \dfrac{V}{sr^2}$	$\Delta = \dfrac{s}{e^{2c/r}-1} - \dfrac{V}{r^2} - h_0$
4	Global maximum if $\Omega_{\Delta=0} < \Omega_{\lambda=0}$	$\lambda = 0$	$\Delta = \dfrac{s}{e^{2c/r}-1} - h_0$
beyond 4	Ω declining, $\Omega \longrightarrow 0$ as $\Delta \longrightarrow \infty$	$\lambda = 0$	$\Delta \geq \dfrac{s}{e^{2c/r}-1} - h_0$

It is interesting to note that while per capita information, I, declines as soon as crowding out of private information acquisition begins (λ<1), this does not necessarily translate into a deterioration of the ability of the price, $\tilde{P}$, to predict the return, $\tilde{u}$. In other words, it is possible to have a local minimum of Ω for (0<λ<1). Let us label this Ω_{min}.

We now proceed to discuss what happens in this model as the public precision increases and how this affects the price. We restate the equation for the pricing error for convenience.

$$\Omega = VAR(\tilde{P} - \tilde{u}) = E\left[\alpha\left(\frac{h_0}{h_0+\Delta}Y_0 + \frac{\Delta}{h_0+\Delta}(\tilde{u}+\tilde{\zeta})\right) + \beta\tilde{u} - \gamma\tilde{X} - \tilde{u}\right]^2$$

where

$$\alpha = \frac{h_0+\Delta}{(h_0+\Delta) + \lambda s + \frac{(r\lambda s)^2}{V}}$$

$$\beta = \frac{\lambda s + \frac{(r\lambda s)^2}{V}}{(h_0+\Delta) + \lambda s + \frac{(r\lambda s)^2}{V}}$$

$$\gamma = \frac{\frac{1}{r} + \frac{r\lambda s}{V}}{(h_0+\Delta) + \lambda s + \frac{(r\lambda s)^2}{V}}$$

Recall that the first and second terms in the price equation can together be seen as the unbiased estimate of the return. The parameters α and β are weights based on the relative precision of the prior knowledge and public signal on the one hand and the private signal and informativeness of the price on the other hand. There are two ways in which an increase of the precision of the public information can undermine the estimate of the return represented by α and β. The first has to do with the public nature of the signal, the second with the fact that private information is costly.

Regarding the first effect, as the precision of the public signal, Δ, increases, traders put more weight on this relative to their private signals. The weight of α increases to the detriment of β. This is individually rational. Collectively, however, it leads to a deterioration of the ability of the price to predict the return. This effect exists because there are an infinite number of traders, all with their own independent signals. Should they all listen only to their private information (β=1) then the infinite number of private errors cancel perfectly when aggregated into the price. However, the more they listen to the public signal, the higher α, the more their individual errors are correlated, which translates into an aggregate error in the price. This is because of the increasing weight on the error resulting from the prior knowledge Y_0-u and the noise in the public signal, ζ.

The second effect has to do with the crowding out of private information acquisition. The numerator of β is dependent on the fraction of informed traders, λ. This is itself dependent on the precision of the public signal, as demonstrated above. As the public signal becomes more precise fewer individual traders buy private information and β declines, to the benefit of α.

The rising precision of the costless public signal thus hurts the ability of the market to predict monetary policy both because it is public and because it is costless. Both effects, however, result in a monotonic relationship between the precision of the public signal and the pricing error. This thus does not explain the phenomenon of a local minimum for $0<\lambda<1$.

That this occurs is the result of the third term. Note that the greater γ the greater the pricing error because the bigger the impact of the uncertain supply, $\tilde{X}$.

The denominator of γ represents per capita information, I. As I declines traders become more worried about supply because uncertainty increases and they are not risk neutral ($r<\infty$). Recall that an increase in the precision of the public signal, Δ, decreases per capita information, I. This means that via the denominator an increase in the precision of the public signal increases γ and thus the pricing error.

The numerator, however, is also affected by the increase in the precision of the public signal. An increase of the public signal pushes down λ and weakens the stochastic influence of X. That λ should have two counteracting repercussions for the influence of supply uncertainty can be thought of as reflecting the risk faced by the uninformed traders that they are dealing with an informed trader. Extra information relieves uncertainty for all traders, but the risk for an uninformed trader of being at an information disadvantage is greater the more informed traders are present. Under the conditions shown above the numerator can dominate temporarily and delay an increase in γ as Δ increases. Thus a local minimum for the interval $0<\lambda<1$ can occur.

Regardless of the above effect, it is clear from the analysis that a local minimum for the pricing error, Ω_{min}, does exist. It is to be found either at $\lambda=1$ or somewhere in the interval $0<\lambda \leq 1$. Low precisions of the public signal, Δ, contribute to a reduction in the pricing error, Ω, until the local minimum is reached; beyond this, medium precisions push up the error, while high precisions push it down again, eventually below the level of the local minimum.

4.3 Implications for policy

The above analysis suggests that providing the market with guidance can lead to crowding out of private information, to the detriment of the predictability of monetary policy. Whether this will actually happen depends not only on the willingness of the central bank to provide guidance on the direction of interest rates but also on its ability to do so.

There is some maximum precision that can be provided on the basis of the information that the central bank has, which we label Δ^*. There are two situations under which it is optimal, from the perspective of the functioning of the financial markets, for the central bank to be fully transparant, i.e. to produce the most precise signal it can, $\Delta=\Delta^*$. The first is if it can only produce an imprecise signal and the second if it can produce a very precise signal.

The first case: if the precision of the public signal is not sufficient to reach the local minimum, Ω_{min}, then a policy of full transparency $\Delta=\Delta^*$ is optimal. The signal is precise enough to add value but not precise enough to increase the pricing error.

The second case: if the maximum precision, Δ^*, is high enough then it is possible for the central bank to eradicate information acquisition ($\lambda=0$) and nonetheless enhance the information in the market. This will happen if the precision of its signal is high enough to compensate its detrimental effects on private information. This signal would have to create a pricing error equal to or below the local minimum for the interval $0< \lambda \leq 1$, Ω_{min}.

Other than these two cases a policy of total transparency, $\Delta=\Delta^*$, is not optimal, at least not in terms of the predicting power of the market. The central bank is in effect crowding out more private information than it can compensate for with its own signal. Optimal from this perspective would be for the central bank to be more reserved in its provision of information, $\Delta<\Delta^*$, and seek to find Δ corresponding to the local minimum, Ω_{min}.

The conclusion is thus that central banks should always provide some guidance on the direction of interest rates. It may be wise to be reserved, however. Only if the central bank knows that it can provide very accurate guidance should it strive for maximum transparency regarding its own interest rate projections.

5 Conclusion

Using the Diamond model we have demonstrated that providing detailed guidance about the direction of monetary policy rates can harm the ability of interest rates to predict policy. A costless public signal from the central bank can crowd out private information. Only if the central bank can provide a sufficiently precise signal about future policy can it compensate for this crowding out. If not, then it might be better to say less than it knows, in order to allow the market room to price in private information.

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