Imperfect Central Bank Communication: Information versus Distraction*

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Abstract

Much of the information communicated by central banks is noisy or imperfect. This paper considers the potential benefits and limitations of central bank communications in a model of imperfect knowledge and learning. It is shown that the value of communicating imperfect information is ambiguous. If the public is able to assess accurately the quality of the imperfect information communicated by a central bank, such communication can inform and improve the public's decisions and expectations. But if not, communicating imperfect communication has the potential to mislead and distract. The risk that imperfect communication may detract from the public's understanding should be considered in the context of a central bank's communications strategy. The risk of distraction means the central bank may prefer to focus its communication policies on the information it knows most about. Indeed, conveying more certain information may improve the public's understanding to the extent that it "crowds out" a role for communicating imperfect information.

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1 Introduction

Over the past two decades, central banks' approach to communications has undergone a sea change. The cultivation of secrecy and mystique has been replaced by a zeal for openness and transparency. Although the benefits of an open and transparent monetary policy process are now widely recognized and understood, most central banks are still grappling with exactly how best to achieve that aim. An approach of "more information is always better" is neither sufficient nor correct. There are costs as well as benefits associated with communicating ever-increasing amounts of noisy and complex information. As central banks seek to continue their progress towards greater openness, these costs and benefits – and their implications for the design of central bank communications – need to be better understood.

This paper considers the potential benefits and limitations of central bank communications in a model which emphasizes two important features of the practical environment in which central banks operate. First, it recognizes that monetary policy is conducted against a backdrop of imperfect knowledge: Central banks and the public have imperfect knowledge about the structure of the economy and about the shocks affecting the economy. Second, it argues that central bank communications should be thought about in terms of communication strategies: All central banks publish some information, the issue faced by central banks is how to combine various types of information in a way that best informs the public. These two features have important implications for the analysis of central bank communications.

That monetary policy is conducted in an environment of imperfect knowledge is central to understanding the potential benefits and limitations of central bank communications. Foremost, it helps to motivate the importance that central banks place on communication policies. As noted by Orphanides and Williams (2006), central bank communications have little role to play in models of rational expectations with perfect knowledge.[1] The recognition that the private sector has imperfect knowledge rationalizes the role central bank communications can play in aiding private sector learning. But the limits on central

[1] In a similar vein, Ben Bernanke, Chairman of the Federal Open Market Committee, recently argued that "Notably, in a world with rational expectations and in which private agents are assumed already to understand all aspects of the economic environment, talking about the effects of central bank communication would not be sensible, whereas models with learning accomodate the analysis of communication-related issues quite well. .... In sum, many of the most interesting issues in contemporary monetary theory require an analytical framework that involves learning by private agents and possibly the central bank as well" (Bernanke, 2007).

banks' knowledge and understanding implies that much of the information communicated by central banks is uncertain or imperfect, such as economic forecasts or short-term policy guidance. This raises important issues concerning the public's ability to process and utilize imperfect, noisy information. Interpreted correctly, the communication of imperfect information can help to inform and improve the public's understanding and expectations. But if the public are not able to assess accurately the quality of the information conveyed by central banks, imperfect central bank communication has the potential to distract and result in worse economic outcomes.[2] Imperfect central bank communication is a doubled-edged sword that should be used with care.

This risk of distraction is most apparent when considered in the context of a central bank's communications strategy. Central banks have a wide range of information at their disposal. All central banks communicate some information; the challenge faced by central banks is to decide which information to publish – and in what form – to best aid the efficient functioning of the economy. An assessment of whether or not to publish a particular piece of information has to be made in the context of the information that is already being communicated. Importantly, the different types of information available to a central bank vary considerably in terms of their precision: Information about a central bank's inflation objective or the outcome of a policy meeting is more precise – less imperfect – than a central bank's economic forecast or guidance about the future path of policy. The risk that the public may be unable to assess correctly the quality of the information being conveyed means that central banks may prefer to communicate more certain information. Indeed, the disclosure of more certain information may "crowd out" a role for communicating imperfect information. That is, it may improve the precision of the public's understanding to a point at which it is no longer beneficial for the central bank to run the risk of communicating imperfect information.

This paper considers the role of central bank communication in an environment of imperfect knowledge and learning. Both the central bank and the private sector are assumed to have imperfect knowledge about the structure of the model and are engaged in perpetual learning. The risk of distraction is explored by considering the effect of publishing central bank forecasts on the accuracy of private-sector inflation expectations. Since both the central bank and the private sector are assumed to have imperfect knowledge of the economy, the central bank's forecasts are not necessarily more accurate than those of the private sector. If the private sector is able to assess correctly the precision of the central bank's

[2] Similar concerns have been expressed by, for example, Issing (1999, 2000), Winkler (2000), Mishkin (2004), Macklem (2005), Woodford (2005), King (2006) and Sibert (2006).

forecasts, publishing the forecasts improves the accuracy of private-sector expectations. But if the private sector is not able to assess the quality of the central bank's forecasts, the value of publishing central bank forecasts is shown to be ambiguous. In particular, the private sector may inadvertently place too much weight on the central bank's forecast and so detract from the accuracy of its expectations.[3] The importance of viewing central bank communications as a strategy comprising numerous pieces of information is illustrated by considering a case in which the central bank is able to announce its inflation objective as well as publish its economic forecasts. It is shown that announcing an inflation target has the potential to "crowd out" a role for publishing economic forecasts.

The remainder of this paper is organized as follows: Section 2 outlines the model and informational assumptions, Section 3 presents the main results, and Section 4 concludes.

2 The model

The model used to explore the effects of central bank communication is highly stylized. Both the central bank and the private sector produce forecasts of inflation. The central bank is assumed to use a structural model as the basis of its forecasting model, whereas the private sector relies solely on a reduced-form forecasting model. The choice of models reflects the dominant forecasting strategies used by central banks and private-sector forecasters respectively in many countries. In particular, the greater value that central banks tend to place on understanding and explaining the "economics" underlying their forecasts means that they often make greater use of structural economic models.[4] But the assumptions concerning the use and choice of different forecasting models is not important for what follows. All that matters is that the forecasts produced by the central bank and the private sector are distinct, and that there is a possibility that the central bank's inflation forecasts may be less accurate than those of the private sector.[5]

Importantly, the models employed by the central bank and private sector are properly specified in the sense that they nest the correct structure of the economy and equilibrium dynamics that would prevail under a rational-expectations equilibrium with perfect knowledge. The central bank and private sector update their model coefficients recursively

[3] As discussed below, these results are qualitatively similar to those of Morris and Shin (2002), although the mechansim underlying the results is very different to that described by Morris and Shin.

[4] See, for example, Harrison *et al.* (2005) for a discussion of the objectives underlying the design of the Bank of England's forecasting model.

[5] Similar results could be obtained, for example, by assuming that the central bank and the private sector used identical forecasting models but received different signals concerning the state of the economy.

using constant gains least squares. This estimation algorithm is equivalent to applying weighted least squares where the weights decline geometrically with time.[6] As discussed by Orphanides and Williams (2004, 2006), the use of constant gain learning – which has the property that learning is a never-ending (perpetual) process – can be justified by the central bank and private sector allowing for the possibility of structural change and therefore placing less weight on older data. Clearly, this is a reasonable assumption even if all of the parameters of the model are stable since, in pratice, there simply is no way for neither the private sector nor the central bank to know if parameters truly are stable. The central bank and private sector recursively update their forecasting models each period and use their most recent estimates to generate inflation forecasts.

The effectiveness of central bank communication is evaluated according to its ability to improve the accuracy of private-sector inflation expectations. If the central bank publishes its inflation forecast, the private sector combines forecasts from its own model with those of the central bank in order to form expectations of future inflation. The weight attached to the central bank's forecast in this combination is determined by the historical forecasting performance of the central bank relative to that of the private sector's model, where importantly that weight is also recursively updated using constant gain learning. That is, the private sector is perpetually learning about the (relative) quality of the central bank's forecasts. If the central bank does not publish its inflation forecast, the private sector's inflation expectations are based solely on its own model forecasts.

The model employed is similar to that used by Orphanides and Williams (2004) but has been extended in several dimensions. Inflation is determined according to a modified Lucas supply function as

$$\pi_t = \phi \pi^e_{t|t-1} + (1-\phi)\,\pi_{t-1} + \alpha x_t + e_t, \tag{1}$$

where π_t is inflation, $\pi^e_{t|t-1}$ is the private sector expectation of time t inflation formed at $t-1$, x_t is the output gap and e_t is a disturbance with properties $e_t \sim nid\left(0, \sigma_e^2\right)$. The output gap for period t is determined by the central bank in period $t-1$ according to its reaction function as

$$x_t = -\theta\left(\pi_{t-1} - \pi^*\right), \tag{2}$$

where π^* is the inflation target of the central bank.

Before considering the forecasting models used by the central bank and private sector, it is useful to clarify the timing of the model. As illustrated in Figure 1, each time period is separated into four subphases. In phase (i), inflation in period t is determined and observed

[6] Sargent (1993, 1999) and Evans and Honkapohja (2001) discuss properites of constant gains learning.

by the central bank and private sector. In phase (ii), the central bank re-estimates its model, produces its forecast for inflation in period $t+1$ and decides whether to publish it. The private sector re-estimates its forecasting model in phase (iii), uses the updated model estimates to generate its inflation forecast, and forms its expectation for inflation in period $t+1$ based on its own inflation forecast and (if published) the central bank's forecast. The private sector's inflation expectations for the next period are observed by the central bank. Finally, in phase (iv), the central bank decides its policy setting (the output gap) for the next period.

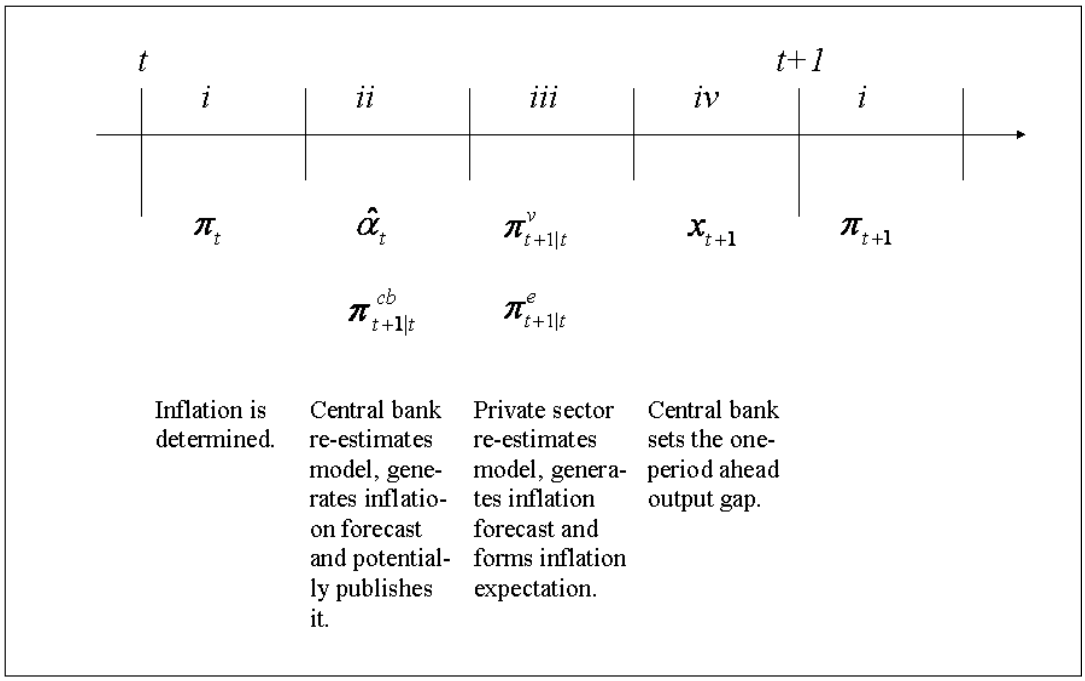

Figure 1: The timing of the model.

The central bank estimates a structural econometric model of the economy, namely the supply function in equation (1). To capture the possibility that central banks have imperfect knowledge of the economy, the central bank is assumed to know the correct form of the supply function and the true value of ϕ, but *not* the value of α.[7] The central bank therefore recursively estimates α each period using constant gain least squares according to

$$\pi_t - \phi\pi^e_{t|t-1} - (1-\phi)\,\pi_{t-1} = \alpha_t x_t + \psi_t. \tag{3}$$

[7]The assumption that the central bank knows ϕ but not α is not particularly realistic but allows us to introduce imperfect knowledge of the central bank in a "minimalistic" way, which is beneficial from a pedagogical viewpoint. Changing several aspects of the model at once can be obscuring as it might be unclear what the relative importance of the different aspects is.

The regression coefficient α_t can be written as

$$\hat{\alpha}_t = \hat{\alpha}_{t-1} + \kappa^{cb} \left(R_t^{cb}\right)^{-1} x_t \left(\pi_t - \phi\pi^e_{t|t-1} - (1-\phi)\,\pi_{t-1} - \hat{\alpha}_{t-1}x_t\right), \tag{4}$$

where

$$R_t^{cb} = R_{t-1}^{cb} + \kappa^{cb}\left(x_t^2 - R_{t-1}^{cb}\right) \tag{5}$$

and κ^{cb} is the gain.[8]

The central bank's inflation forecast is given by

$$\pi^{cb}_{t+1|t} = \frac{\hat{\alpha}_t\theta}{1-\phi}\pi^* + \frac{1-\phi-\hat{\alpha}_t\theta}{1-\phi}\pi_t, \tag{6}$$

where this forecast assumes that private-sector inflation expectations are formed according to the central banks' estimate of the reduced-form relationship that would be the solution under full information and rational expectations.[9]

The private sector generates inflation forecasts using the AR(1) model

$$\pi_t = c_{0,t} + c_{1,t}\pi_{t-1} + v_t \tag{7}$$

Just like the central bank, the private sector recursively updates its model estimates each period using constant gain least squares and we can express the regression coefficients $\hat{c}_t = (\hat{c}_{0,t}, \hat{c}_{1,t})'$ as

$$\hat{c}_t = \hat{c}_{t-1} + \kappa^v R_t^{-1} X_t \left(\pi_t - X_t'\hat{c}_{t-1}\right) \tag{8}$$

where

$$R_t = R_{t-1} + \kappa^v\left(X_tX_t' - R_{t-1}\right), \tag{9}$$

κ^v is the gain and $X_t = (1, \pi_{t-1})$.

The model in equation (7) is then used to generate a model-based forecast for inflation according to

$$\pi^v_{t+1|t} = \hat{c}_{0,t} + \hat{c}_{1,t}\pi_t. \tag{10}$$

If the central bank does not publish its inflation forecast, the private sector's inflation expectation is simply formed as $\pi^e_{t+1|t} = \pi^v_{t+1|t}$. In general though, we let the private sector's expectation for inflation be based on both its own inflation forecast and the forecast published by the central bank. In particular, the private sector combines its own least squares forecast in equation (10) with the central bank's according to

$$\pi^e_{t+1|t} = \gamma_t\pi^v_{t+1|t} + (1-\gamma_t)\,\pi^{cb}_{t+1|t}. \tag{11}$$

[8] This learning algorithm is standard in the literature; see, for example, Evans and Honkapohja (2001).

[9] This assumption is made for simplicity. In principle, the central bank could, for example, estimate a separate forecasting model for private-sector expectations and use this together with the structural model as the basis for its inflation forecasts. This would not affect the main qualitative results discussed here.

In line with the principle of "optimal weights" suggested by Granger and Ramanathan (1984), the weight γ_t in this forecast combination is determined by the relative historical forecasting performances of the private sector and central bank. However, given that the private sector is assumed to be perpetually learning about the structure of the economy, rather than using fixed weights for the forecast combination, the private sector updates the weight each period as suggested by Diebold and Pauly (1987). Assuming that both the private sector and the central bank are generating unbiased forecasts, the private sector establishes γ_t by running the regression

$$\pi_t - \pi_t^{cb} = g_t \left(\pi_{t|t-1}^{v} - \pi_t^{cb} \right) + \chi_t \tag{12}$$

using constant gain least squares; the gain in this procedure is denoted κ^f.[10] For $0 \leq \hat{g}_t \leq 1$ the private sector sets $\gamma_t = \hat{g}_t$, for $\hat{g}_t < 0$ it sets $\gamma_t = 0$ and for $\hat{g}_t > 1$ it sets $\gamma_t = 1$.

3 Results

We start by exploring the limiting case in which the forecasting models used by both the central bank and the private sector accurately describe the dynamics of inflation. In this case, the central bank and the private sector arrive independently at identical inflation forecasts and central bank communication has no role to play. This limiting case, which mimics the rational-expectations, perfect knowledge outcome, serves as a benchmark against which to consider the impact of imperfect knowledge and central bank communications. We next turn to the intermediate case in which the central bank has perfect knowledge about the structure of the economy and uses its forecasts to help inform the private sector. The benefits of central bank communications depend on the ability of agents to assess the quality of the information being conveyed. We then explore the role of central bank communications in our main case, in which both the central bank and the private sector have imperfect knowledge about the structure of the economy. We first explore the risk of distraction in the case in which the central bank has only one piece of information which it is able to communicate – its inflation forecast. We show that publishing the central bank's forecast has an ambiguous impact on the accuracy of private sector expectations depending on the relative precision of the central bank and private sector forecasts. We then consider the value of publishing the central bank forecast in the context of a communications strategy

[10] Interpreted literally, the suggestion that the private sector may practice constant gain learning because of the possibility of structural change implies that κ^v should equal κ^f. But we allow for the possibility that $\kappa^v \neq \kappa^f$ to explore circumstances in which the ability of the private sector to assess the quality of central bank forecasts may differ from their ability to produce their own forecasts.

in which the central bank is also able to announce its inflation target. We show that announcing an inflation target may "crowd out" a role for publishing the central bank's economic forecasts.

In the baseline simulations, the parameters of the supply function are set to $\phi = \alpha = 0.5$ and we let the error term have variance $\sigma_e^2 = 1$. The responsiveness of monetary policy (in the form of the output gap) to the inflation gap is set to $\theta = 0.6$.[11] The gains used by the private sector in equations (7) and (12) are set to $\kappa^v = \kappa^f = 0.03$.[12] The effectiveness of central bank communication is evaluated by the accuracy of private sector inflation expectations, measured by their RMSE.[13] For each combination of parameters, the economy was simulated for $T = 160\ 000$ time periods; the first 80 000 observations were discarded and the analysis accordingly based on the second half of each sample.

3.1 Perfect knowledge benchmark

The forecasting models used by the central bank and private sector nest the correct structure of the economy that would prevail under full information and rational expectations. The rational expectations, full-information benchmark can hence be obtained by setting the gains used by the central bank and private sector in estimating their forecasting models to be inversely related to the age of the data, $\kappa^{cb} = \kappa^v = 1/t$, so as t increases, κ^{cb} and κ^v converge to zero.[14] In this case, the estimation algorithms used by the central bank and private sector collapse to more conventional least squares learning with infinite memory, and thus the estimates of the two forecasting models converge to their correct values and the perfect-knowledge benchmark solution is obtained. The central bank and private sector produce identical forecasts for inflation and, as such, there is no role for central bank communication. As reported in Table 1, the RMSE of private sector inflation expectations

[11] A value of $\theta = 0.6$ would be close to optimal in the case of full information and rational expectations if the central bank was trying to minimize a conventional loss function of the type $\mathcal{L} = \omega Var(\pi_t - \pi^*) + (1-\omega) Var(y_t)$ with $\omega = 0.5$; see, for example, Orphanides and Williams (2004).

[12] Recall that the model is highly stylized and the results are meant only to be illustrative. However, to aid interpretation, the calibration of the supply function ($\phi = \alpha = 0.5$) is similar to estimates reported by Orphanides and Williams (2006) using quartely U.S. data. To the extent that the model can be interpreted as quarterly, a value, for example, of $\kappa^v = 0.03$ implies that the private sector bases its model estimates on roughly sixteen years of data. See Orphanides and Williams (2004, 2006) for a discussion of the interpretation of, and plausible values for, private sector gain.

[13] The root-mean squared error of the central bank's forecasts, private sector's forecast, and private sector's expectations are denoted $RMSE_{\pi^{cb}_{t|t-1}}$, $RMSE_{\pi^{v}_{t|t-1}}$ and $RMSE_{\pi^{e}_{t|t-1}}$ respectively.

[14] Where t denotes the distance in time between the observation being weighted and the current observation.

in this case is governed by the variance of the shocks affecting the economy.[15]

3.2 Intermediate case: Private sector imperfect knowledge

Consider now the intermediate case in which the central bank's knowledge of the economy is assumed to converge to the full-information case as data accumulate (i.e. $\kappa^{cb} = 1/t$), but the private sector is perpetually learning about the economy.

If the central bank does not publish its forecast, the private sector bases its expectations solely on its own least squares forecasts from equation (10), such that $\pi^{e}_{t+1|t} = \pi^{v}_{t+1|t}$. The results presented in Table 2 show how the RMSE of the private sector forecast, not surprisingly, is increasing with the gain used in its least squares algorithm. That is, as the private sector restricts the use its makes of historical data in estimating its forecast model – as κ^{v} increases – the precision of its forecasts (and hence its expectations) deteriorates.[16]

Alternatively, if the central bank publishes its forecasts, the private sector now needs to recursively update estimates of both its forecast model (7) and the weight to attach to the central bank's forecast when forming its inflation expectations. Table 3 shows the effect of publishing the central bank's forecast on the RMSE of private sector inflation expectations when $\kappa^{v} = \kappa^{f}$. Comparing the outcomes reported in Tables 2 and 3, it can be seen that it is unambiguously beneficial for the central bank to publish its forecast. The central bank has an informational advantage which it can use to help inform private-sector expectations.

The extent of that benefit depends on the private sector's ability to recognize the true value of this forecast. This can be illustrated by varying the gain κ^{f} used by the private sector to estimate the weight to attach to the central bank's forecast.[17] Table 4 shows that as the private sector's ability to evaluate the quality of the central bank's information improves – that is, the value of κ^{f} falls – the private sector attaches increasing weight to the central bank's forecast and the precision of its inflation expectations correspondingly improves.

[15] The RMSEs are very close to the true value of σ^{2}_{e}. The deviation is due to random error – this has been established by choosing different random number seeds.

[16] As can be seen from Table 2, the forecasting performance of the central bank also deteriorates as κ^{v} increases. This reflects the fact that, given the structure of the model, the forecasting performance of the central bank and private sector will typically depend on each other.

[17] For simplicity, the gain used by the private sector to estimate its forecasting model (7) is held constant at $\kappa^{v} = 0.03$.

3.3 Main case: Central bank and private sector imperfect knowledge

We turn now to our central case in which both the central bank and the private sector are assumed to be perpetually learning about the economy. We start by continuing to consider the case in which the central bank is able to communicate only its inflation forecast. That the central bank also has imperfect knowledge about the economy means that the central bank's forecasts may not necessarily be more precise than those of the private sector. This gives rise to the possibility that if the central bank's forecast is relatively noisy and the private sector inadvertently places too much weight on this forecast, publishing the central bank's forecast may detract from the accuracy of private sector expectations: It may act as a source of distraction.

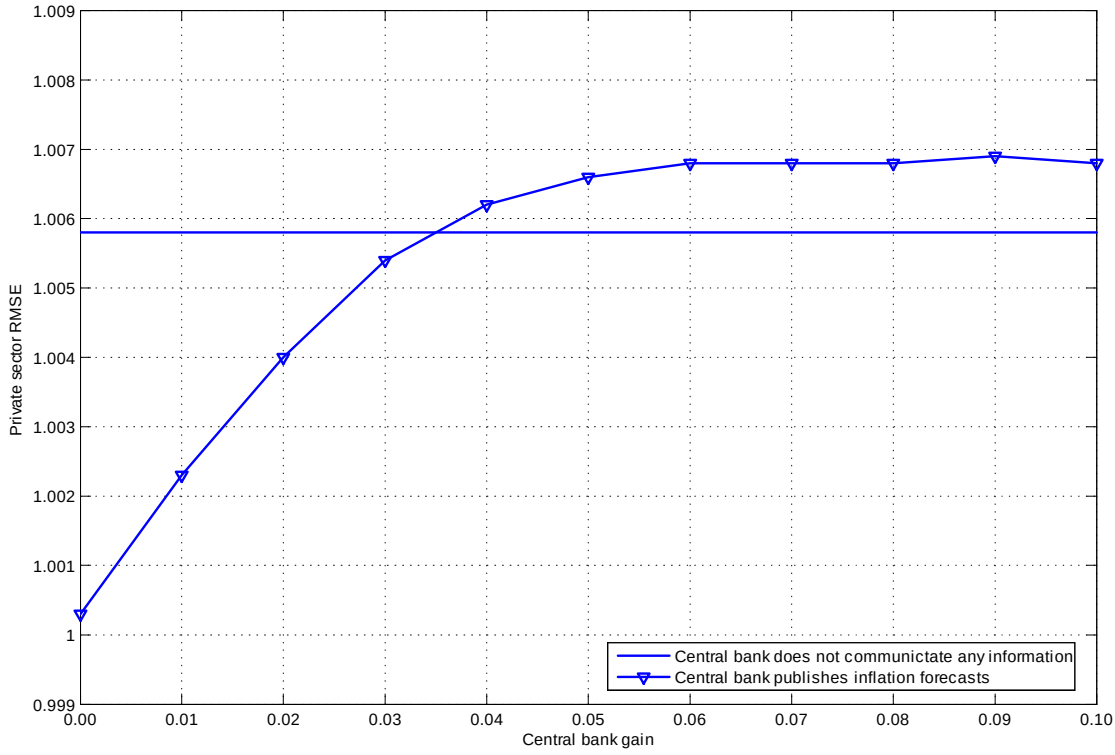

Figure 2: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.60$.

The effect of publishing central bank forecasts on the RMSE of private-sector expectations is shown by the upward sloping line in Figure 2.[18] As in the intermediate case, the private sector is assumed to update its forecasting equation (7) each period using constant

[18] More detailed results are given in Tables 5 and 6.

gain learning and forms its inflation expectations by combining its own inflation forecast with the central bank's forecast; in doing this, the gains κ^v and κ^f are both fixed at 0.03. The effect of varying the quality of the central bank's forecast is illustrated by varying the gain used by the central bank κ^{cb}; as κ^{cb} increases, the central bank makes less use of historical data to estimate its forecasting model and so the quality of its forecasts deteriorates. By way of comparison, the RMSE of private sector expectations in the case in which the central bank does not publish its inflation forecast is shown by the horizontal line.

Not surprisingly, when the central bank's forecasts are relatively accurate – that is, the central bank gain κ^{cb} is relatively low – publishing the central bank's forecasts improves the accuracy of private sector expectations relative to the case in which they are not published. However, if the accuracy of the central bank's forecast deteriorates beyond a certain point then it is better for the central bank not to publish its forecast. That is, the RMSE of private sector expectations is lower in the case in which the forecast is not published. The possibility that publishing central bank forecasts may detract from the accuracy of private sector expectations stems from the imperfect ability of the private sector to assess the quality of the forecasts. The private sector is perpetually having to learn about the relative quality of the central bank's forecasts and so there is a risk that it may attach too little or too much weight to the central bank forecast relative to its own forecast. If the private sector attaches too little weight, publishing the central bank forecast still helps to improve the accuracy of private-sector expectations, but not by its full potential. In contrast, if the private sector attaches too much weight to the central bank forecast, there is a risk that it will detract from the accuracy of its expectations.

The point at which publishing the central bank's forecast may act as a source of distraction rests on two key factors. First, it depends on the precision of the central bank's forecasts relative to that of the private sector. As the relative quality of the central bank's forecasts deteriorate, there is a greater chance that publishing the forecasts will distract the private sector.[19] Figure 3 and Table 5 illustrate the effect of publishing the central bank's forecasts for three different levels of precision of private sector forecasts (proxied by varying the gain used by the private sector in the algorithm used to estimate its forecasting model: $\kappa^v = (0.01,\ 0.03,\ 0.05)$).[20] As the precision of private sector forecasts improves – that is,

[19] As the relative quality of the private sector forecast increases, the "optimal" weight to place on the central bank forecast falls. Given that the weight that can be placed on the central bank's forecast has a lower bound of zero this implies that, as the relative quality of the private sector forecast increases, the distribution of γ_t around the "optimal" weight becomes increasingly positively skewed.

[20] For simplicity, the ability of the private sector to assess the relative quality of the central bank and private sector forecasts (proxied by κ^f) is held constant, at $\kappa^f = 0.03$, in all three cases.

the value of κ^v declines – the minimum level of accuracy necessary for it to be beneficial for the central bank to publish its forecast becomes more strenuous.[21]

Second, the value of the central bank publishing its forecasts depends on the ability of the private sector to evaluate their quality. If the private sector's ability to assess the true quality of the imperfect information being communicated is relatively limited, there is a greater chance that publishing noisy economic forecasts will mislead the private sector. This is shown in Figure 4 and Table 6 which illustrate the effect of varying the gain κ^f used by the private sector to estimate the weight to attach to the central bank's forecasts.[22] As the ability of the private sector to assess the quality of central bank forecasts falls – that is, κ^f rises – it becomes increasingly likely that publishing noisy economic forecasts may distract the private sector.

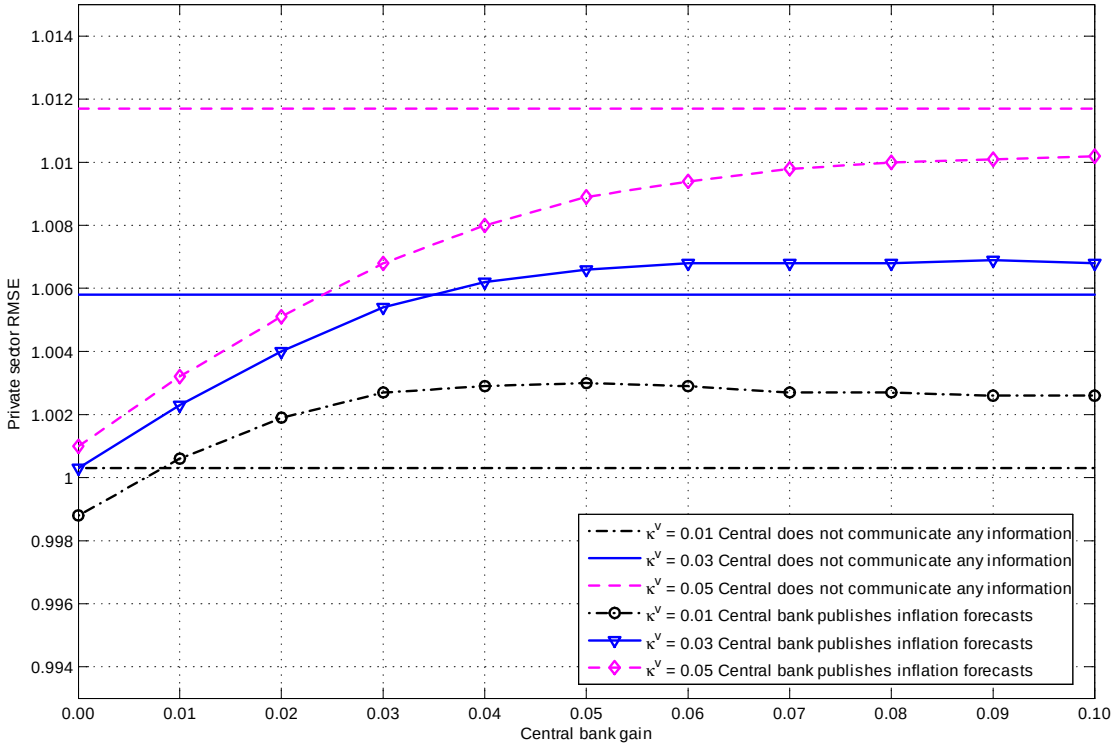

Figure 3: Private sector RMSEs under different communicaiton strategies. Private sector gain used to combined forecasts is 0.03. $\theta = 0.60$.

Several points about these results are worth noting. First, the risk that communicating

[21] In the case of $\kappa^v = 0.05$, the relatively poor quality of private-sector forecasts means that it is beneficial to publish central bank forecasts even when the central bank gain increases to $\kappa^{cb} = 0.10$.

[22] Three different values are considered – $\kappa^f = (0.01,\ 0.03,\ 0.05)$ – while κ^v is kept fixed at 0.03.

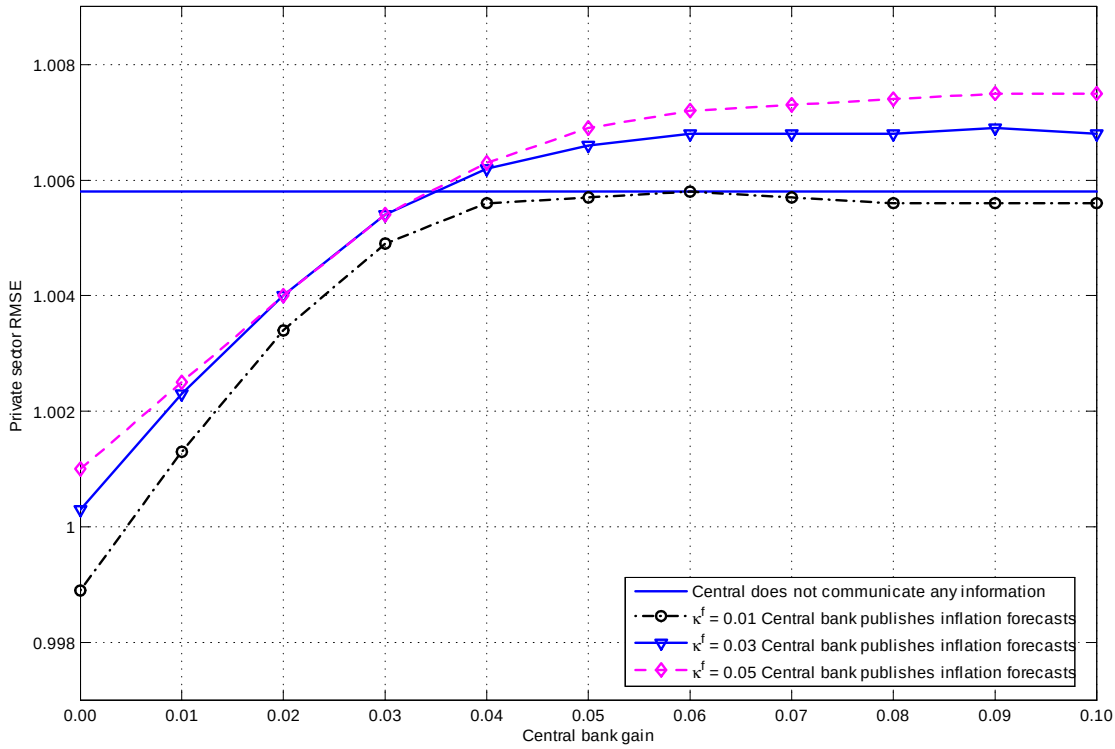

Figure 4: Private sector RMSEs under different communicaiton strategies. Private sector gain used to estimate AR(1) model is 0.03. $\theta = 0.60$.

imperfect information may act as a source of distraction arises because the private sector is not able to assess correctly the relative quality of that information. This raises the question of whether central banks are able to provide greater guidance about the relative quality of the information they communicate. Indeed, it is notable that central banks in recent years have made considerable efforts to convey the uncertainty associated with some of their communications, such as with the use of so-called "fan charts" to illustrate the subjective probability distribution associated with their forecasts. But although a central bank may be able to make estimates about the *absolute* precision of some of its communications, that is very different to being able to provide estimates of the *relative* precision of that information, which is likely to vary substantially across different sectors of society. And the ability of central banks to form estimates of even the absolute precision of much of the qualitative information they communicate, such as speeches by policymakers or the minutes of policy meetings, is likely to be very limited. Thus, while efforts by central banks to convey the uncertainty of the information they communicate may help to mitigate this problem, it is unlikely to represent a complete solution.

Second, these results are qualitatively similar to those of Morris and Shin (2002) (MS), who show that the welfare effects of increased public disclosures are ambiguous. In particular, they argue that "the better informed is the private sector, the higher is the hurdle rate of precision of public information that would make it welfare enhancing" (Morris and Shin, 2002). But the mechanism underlying the MS result is very different to that considered here. MS is based around a model of information heterogeneity in which agents are assumed to have a coordination motive arising from a strategic complementarity in their actions. The role that public information serves as a focal point for beliefs leads agents to attach excessive weight to such information. Thus, as the relative precision of the public signal deteriorates, the provision of public information can be detrimental to welfare. In the model considered here, the possibility that the private sector may attach the incorrect weight to central bank information stems from their imperfect ability to assess the quality of such information: Agents may attach too much or too little weight to the information. As the relative precision of the central bank information declines, the costs associated with attaching too much weight to the information increase, such that there is growing risk that central bank communications may act as a source of distraction.

Finally, the results discussed so far have stressed the *qualitative* implications of the model. The highly stylized nature of the model limits the inferences that can usefully be drawn about its *quantitative* implications. In particular, the simplistic nature of the model means that the results should not be interpreted as applying literally to the relative forecasting performance of central banks. The model ignores many of the channels through which central bank economic forecasts may help to guide and inform private-sector expectations. However, it is possible to use the ratio of the RMSE of the central bank and private sector forecasts as a rough gauge of the relative precision at which it may become potentially harmful for a central bank to communicate imperfect information. To that extent, the results presented in Tables 5 and 6 suggest that central bank information need only be slightly less precise than that of the private sector for it to be potentially harmful to communicate. Thus, in the context of Svensson's (2006) response to Morris and Shin (2002), the results suggest that the information being communicated by a central bank need not diverge very far from the "conservative benchmark" of equal precision for it to risk distracting the private sector. Moreover, when considering the relative precision of the marginal piece of information that can be communicated, it is important that it is evaluated in the context of the information that is already being conveyed, that is, in terms of the central bank's existing communications strategy. We turn to this issue next.

3.4 Communication strategies

So far we have assumed that the central bank has only one piece of information that it can potentially communicate, namely its inflation forecasts. Thus the central bank's communication strategy boils down to a binary decision of whether or not to communicate. But in practice all central banks communicate some information. The challenge faced by central banks is to design a communications strategy which combines various types of information in a way that helps to inform private sector expectations in an efficient and effective manner. The importance of analyzing central bank communications in the context of a communications strategy can be illustrated by considering the case in which the central bank now has the ability to announce its inflation target (π^*), as well as publish its inflation forecast.

To the private sector, knowledge of the inflation target means that it no longer has to estimate the intercept in its econometric model.[23] It can accordingly estimate the restricted model

$$\pi_t - \pi^* = c_{1,t}\left(\pi_{t-1} - \pi^*\right) + v_t \tag{13}$$

and forecasts based on this constant gain least squares estimation are generated as

$$\pi^v_{t+1|t} = \left(1 - \hat{c}_{1,t}\right)\pi^* + \hat{c}_{1,t}\pi_t. \tag{14}$$

The private sector continues to form its inflation expectations by combining its private forecasts with the central bank's forecasts in the same way as that described earlier.

Figure 5 considers the effect of four alternative communication strategies on the RMSE of private sector expectations.[24] As before, the private sector is assumed to be perpetually learning about both the structure of the economy and about the relative quality of the central bank's forecasts; the gains used by the private sector are set to $\kappa^v = \kappa^f = 0.03$. The upper two blue lines simply repeat the first results regarding communication strategies considered in Section 3.3. The horizontal blue line shows the case in which the central bank does not communicate any information and the upward sloping blue line the case in which the central bank publishes only its inflation forecasts. The lower two pink lines illustrate the effect of communication strategies which involve announcing an inflation target. The horizontal pink line shows the case in which the central bank announces only its inflation target and the upward-sloping pink line considers the outcome of a communications strategy

[23] For simplicity, we assume that that the announcement of the inflation target is perfectly credible. Allowing for the possibility of imperfect credibility – for example, by letting only a share of the private sector impose the restriction – would not affect the qualitative results.

[24] Results are also shown in Tables 7 and 8.

in which the central bank both announces its inflation target and publishes its inflation forecasts.

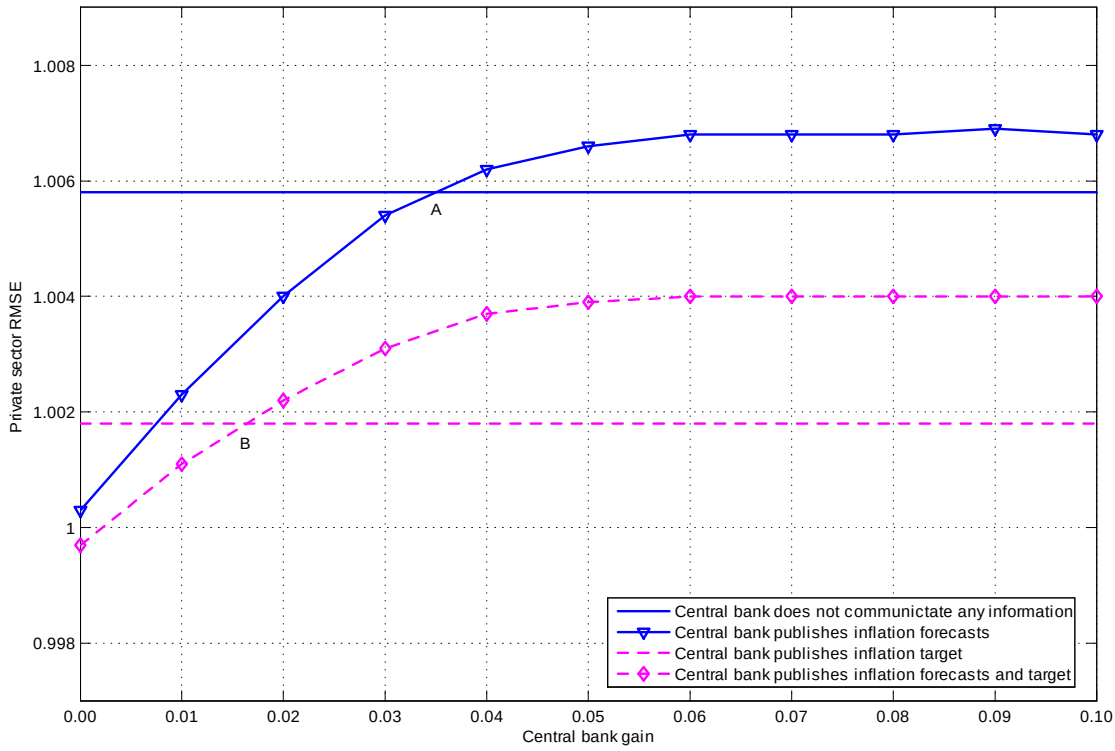

Figure 5: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.60$.

Not surprisingly, the communication strategies which include the announcement of an inflation target are unambiguously better than those which do not: Communicating information known with certainty, such as an inflation target, means there is no risk that the private sector will place too much weight on that information.[25] Moreover, comparing the communication strategies which involve announcing an inflation target, it is clear that the benefit of publishing the central bank's inflation forecast remains ambiguous. Once the accuracy of the central bank's forecasts falls below a certain level it is better for the central bank to announce only its inflation target, rather than also publish its inflation forecast.

The importance of viewing central bank communications in the context of an overall

[25] This assumes that the central bank is genuinely committed to achieving the announced inflation target. It also assumes that the private sector's knowledge of the economy is such that it is able to utilize this information correctly. It is possible that the private sector may place too little weight on the inflation target, that is, the target is not perfectly credible. But, as noted above, this possibility does not affect the qualitative results.

communications strategy can be seen by considering the central bank's decision of whether or not to publish its inflation forecast. In particular, the minimum standard of accuracy required for it to be beneficial for the central bank to publish its inflation forecasts is more strenuous in the case in which the central bank announces an inflation target than in the case in which it does not. This is shown in Figure 5 by the fact that the level of central bank gain κ^{cb} at which the forecasts start to detract from the accuracy of private sector expectations is lower when the central bank announces its inflation target than in the case in which it does not; the difference is given by the horizontal distance between points A and B. The intuition for this result stems directly from the fact that the benefits (and costs) of publishing the central bank's forecasts depend on the *relative* accuracy of the central bank and private sector forecasts. By announcing its inflation target, the central bank improves the accuracy of the private sector's forecasts and so increases the risk that publishing its inflation forecasts will act as a source of distraction. Put more generally, the ability of the central bank to communicate more certain information has the potential to "crowd out" a role for communicating imperfect information.

An important implication of this crowding out result is that as more information is communicated by a central bank – and absorbed by the private sector – there is an increasing risk that the marginal piece of information conveyed by the central bank may act as a source of distraction.[26] This will be the case even if the quality of the information being communicated does not deteriorate. If, as seems likely, the precision of the marginal piece of information deteriorates as central banks communicate more information, this further heightens the risk that communicating ever-increasing amounts of information may act as a source of distraction.

4 Conclusions

Mystique and secrecy are truly no longer the bywords of central banking. The importance of open and transparent policy processes are widely recognized and understood. Central banks have made huge strides in their communication policies over the past two decades. But for

[26] This stems from the recognition that central bank communication can aid private sector learning, that is, the accuracy of the private sector's forecasts depends on the information communicated by the central bank. In contrast, under the heterogenous information assumptions employed by Morris and Shin (2002) among others, the precision of the private sector's information is independent of the information communicated by the central bank. The endogeneity of the private sector's understanding generated by this learning mechanism underpins the importance of considering central bank communication in the context of the overall communications strategy.

many central banks, communications remain a "work in progress" (Bernanke 2007). There is a need to better understand the design and evaluation of central bank communication policies. The mantra of "more information is always better" is neither sufficient nor correct.

This paper considers the role of central bank communications in a model of imperfect knowledge and learning. The recognition that monetary policy is conducted in an environment of imperfect information is central to understanding both the potential benefits and limitations of central bank communications. It rationalizes the role central bank communications may play in helping to inform private sector decisions and expectations. But it also serves to emphasize that much of the information communicated by central banks is noisy and imperfect. Such imperfect information can inform and improve the public's understanding. However, unless interpreted correctly, it also has the potential to distract and mislead. Imperfect central bank communication is a double-edged sword that should be used with care.

The possibility that central bank communications may detract from the public's understanding is most apparent when viewed in the context of a communications strategy comprising numerous pieces of information. As more information is conveyed by central banks – and understood by the public – the benefits of increased communication have to be weighed against the growing risk that they will act as a source of distraction.

The central policy message of this paper is that there may be costs – as well as benefits – associated with publishing ever increasing amounts of uncertain and noisy information. If the information is too noisy relative to the private sector's existing understanding, it may be better for the central bank not to communicate it. This message may strike many policymakers and central bank officials as little more than common sense – we agree. But it is important to understand and demonstrate the mechanisms that may give rise to it. Communicating imperfect information may be detrimental because of the limited ability of the private sector to assess correctly the quality of that information. This suggests that central banks should focus their communication policies on the information they know most about.

The model considered in this paper is highly stylized and the results should not be interpreted as literally suggesting that publishing central bank forecasts is, as a practical matter, likely to mislead the public. Indeed, the fact that central banks in every advanced economy now publish some form of economic forecasts suggests that experience has led central banks to conclude that publishing information about their forecasts is useful in informing private sector decisions and expectations. However, the risk of distraction may help to rationalize why many central banks tend to limit the amount of forecast information

they publish to two or three key variables rather than provide detailed numerical forecasts for a large number of variables. Likewise, it may help to explain why many central banks appear more circumspect about publishing forecasts for the output gap or for the path of their policy rate.

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5 Appendix

5.1 Changing the structure of the economy

As stressed in the main part of the paper, the model considered here is highly stylized, and as such the quantitative results are likely to depend on its precise parameterization. To illustrate this sensitivity, consider first the effect of varying the responsiveness of the output gap to the inflation gap, that is, the value of θ.[27] Two alternative values of θ are considered – $\theta = 0.40$ and $\theta = 0.83$ – compared with the benchmark case of $\theta = 0.60$. The results for the perfect knowledge benchmark and for the case in which the central bank does not communicate any information are reported in Tables 9 and 10 respectively. Results for the cases in which the central bank publishes its inflation forecasts and/or announces its inflation target are shown in Tables 11 to 15.[28]

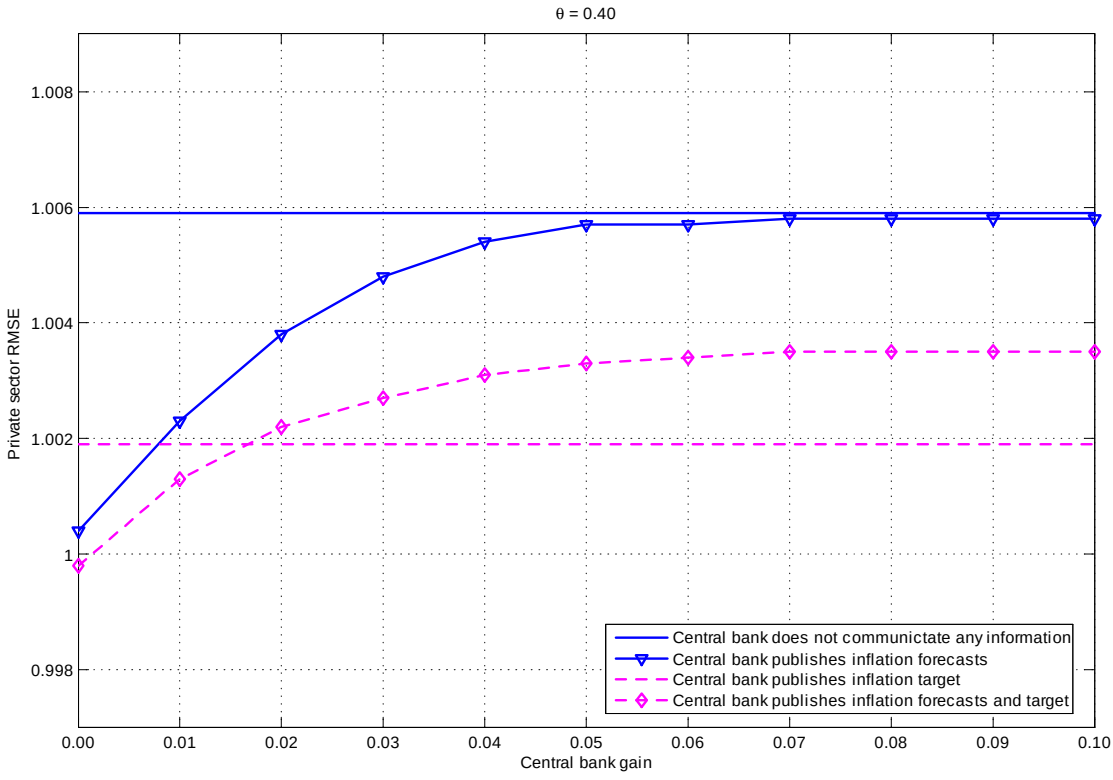

Figure 6: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.40$.

[27] Varying the value of ϕ would affect the dynamics of inflation in a qualitatively similar way.

[28] Note that in all cases except full information and rational expectations, the private sector is assumed to have gains of $\kappa^v = \kappa^f = 0.03$.

The results for $\theta = 0.40$ are summarized in Figure 6. The qualitative results are broadly similar to those discussed in the main part of the paper, although it is interesting to note that reducing the responsiveness of the output gap to the inflation gap improves the relative performance of the central bank's forecasts. As a result, for the range of central bank gains considered here, it is always beneficial for the central bank to publish its forecasts relative to an alternative strategy of no communication. If we allow for the possibility that the central bank may be able to announce its inflation target, the benefit of the central bank publishing economic forecasts is once again ambiguous.

The results for $\theta = 0.83$ – summarized in Figure 7 – are qualitatively similar to those in the benchmark case.

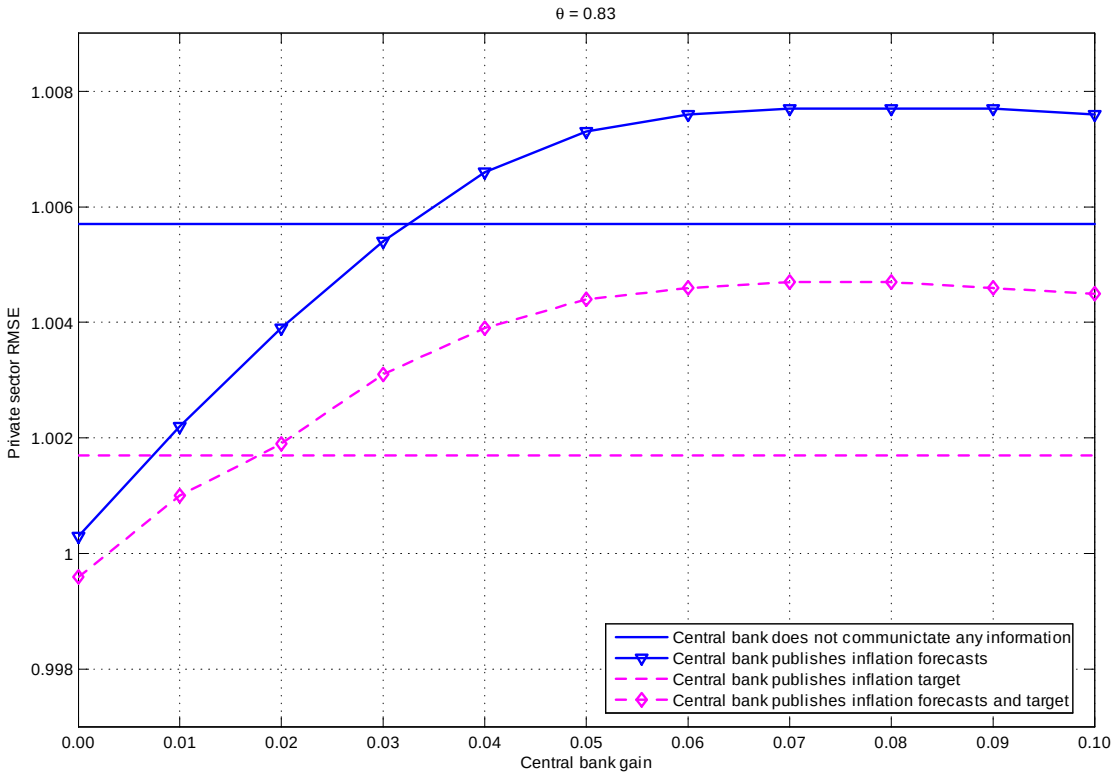

Figure 7: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.83$.

5.2 Changing the private sector gain

As a further sensitivity analysis, consider the effects of changing the gains used by the private sector. In particular, instead of the benchmark values of $\kappa = \kappa^f = 0.03$, consider the effect of the private sector using significantly smaller ($\kappa^v = \kappa^f = 0.01$) or larger ($\kappa^v$

$= \kappa^f = 0.10$) private sector gains.[29] Results are reported in Figures 8 and 9, and Tables 16 to 19.

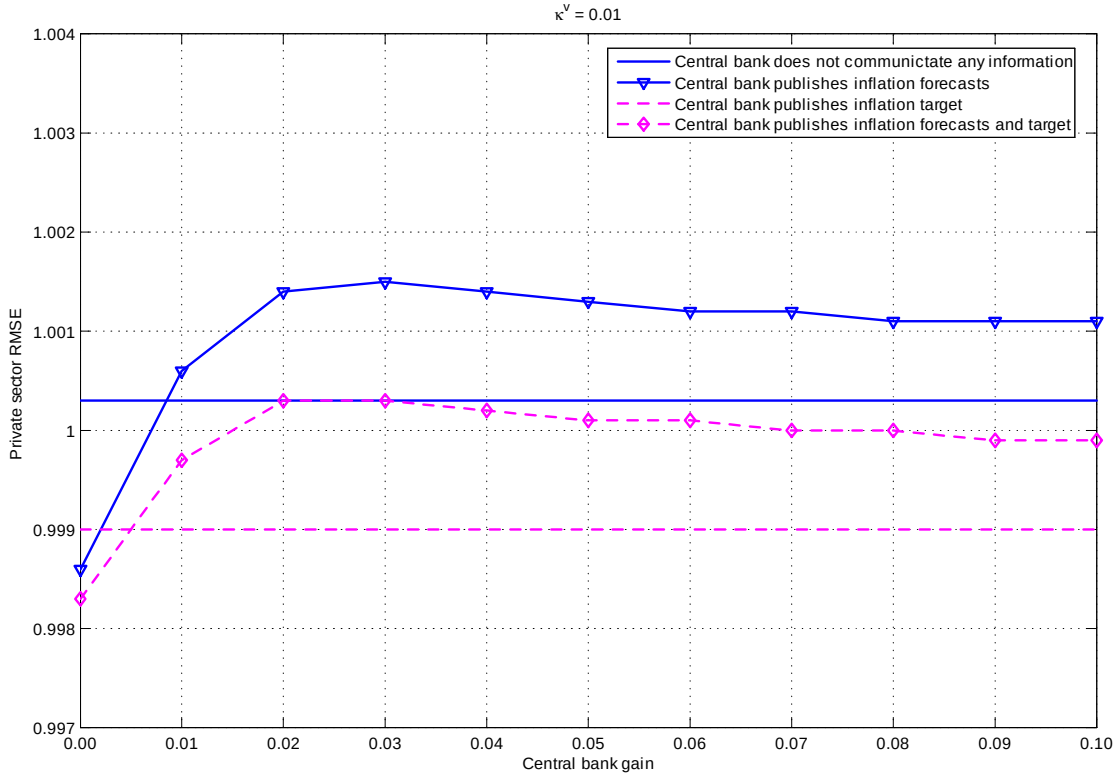

Figure 8: Private sector RMSEs under different communication strategies. Private sector gains are equal to 0.01. $\theta = 0.60$.

As would be expected, allowing the private sector to reduce its gain to only $\kappa^v = \kappa^f = 0.01$ greatly improves the precision of the private sector's inflation expectations; the RMSEs under different communication strategies shown in Figure 8 are noticeably lower than those in the corresponding benchmark case. For it to be beneficial for the central bank to publish its forecasts, the central bank's gain now has to be very small.

The reverse is the case when the private sector is forced to use the relatively high gain of $\kappa^v = \kappa^f = 0.10$, shown in Figure 9. Indeed, the extent of the private sector's uncertainty means that for the range of central bank gains considered here, it is now always beneficial for the central bank to publish its forecasts.

[29] The responsiveness of the output gap to the inflation gap is set to the benchmark value of $\theta = 0.6$.

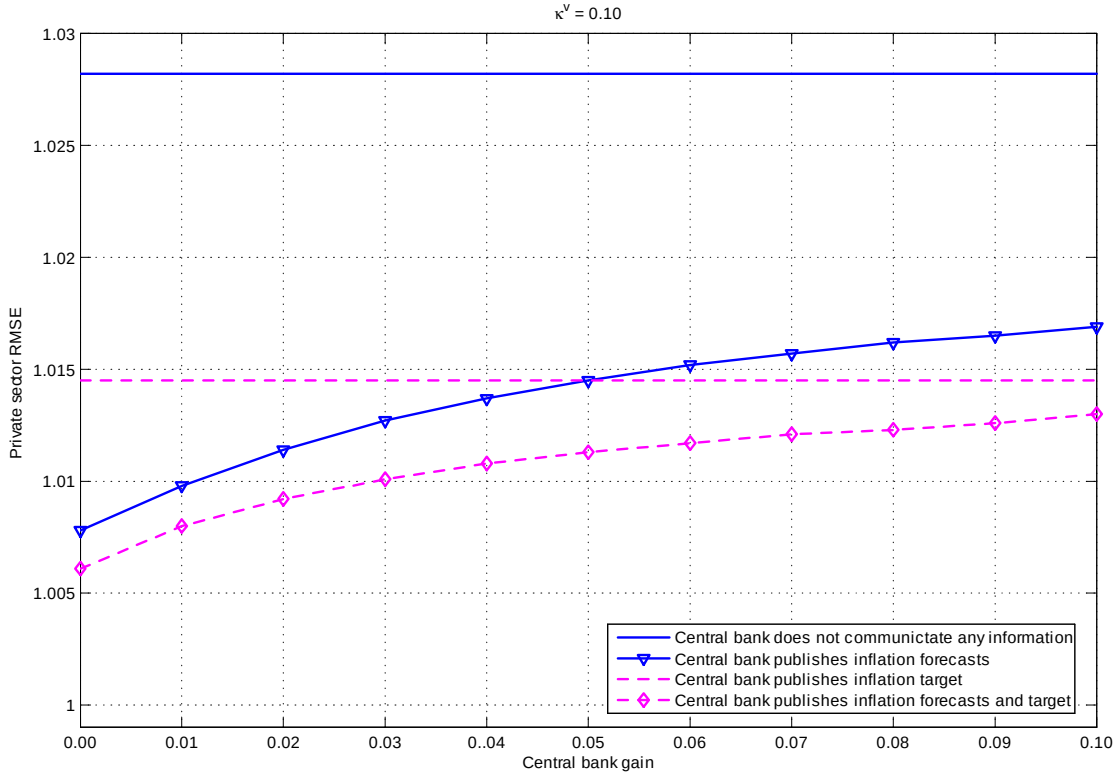

Figure 9: Private sector RMSEs under different communication strategies. Private sector gains are equal to 0.10. $\theta = 0.60$.

5.3 Tables

Table 1: Perfect knowledge benchmark.

$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.998	0.998	0.998

Notes: Central bank and private sector both know all parameters of the model. Responsiveness of the output gap to the inflation gap is 0.60.

5.3.1 Intermediate case: Private sector imperfect knowledge

Table 2: Central bank does not communicate any information.

κ^v	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.01	1.000	1.000	1.000
0.03	1.006	1.006	1.006
0.05	1.012	1.012	1.012

Notes: Central bank gain is equal to 0. Responsiveness of the output gap to the inflation gap is 0.60.

Table 3: Central bank publishes inflation forecasts.

$\kappa^v = \kappa^f$	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.01	0.247	0.999	1.002	0.999
0.03	0.250	1.000	1.010	1.001
0.05	0.249	1.002	1.019	1.003

Notes: Central bank gain is equal to 0. Responsiveness of the output gap to the inflation gap is 0.60.

Table 4: Central bank publishes inflation forecasts: Effect of varying κ^f.

κ^f	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.01	0.189	0.999	1.011	0.999
0.03	0.250	1.000	1.010	1.001
0.05	0.275	1.001	1.010	1.002

Notes: Central bank gain is equal to 0. Private sector gain used to estimate AR(1) model is 0.03. Responsiveness of the output gap to the inflation gap is 0.60.

5.3.2 Main case: Central bank and private sector imperfect knowledge

Table 5: Central bank publishes inflation forecasts: Effect of varying κ^v and κ^{cb}.

κ^v	κ^{cb}	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.01	0.00	0.301	0.999	1.002	0.999
0.01	0.02	0.610	1.002	1.002	1.005
0.01	0.04	0.698	1.003	1.003	1.014
0.01	0.06	0.715	1.003	1.003	1.022
0.01	0.08	0.718	1.003	1.004	1.027
0.01	0.10	0.722	1.003	1.0034	1.031
0.03	0.00	0.250	1.000	1.010	1.001
0.03	0.02	0.312	1.004	1.007	1.004
0.03	0.04	0.498	1.006	1.008	1.011
0.03	0.06	0.582	1.007	1.008	1.017
0.03	0.08	0.610	1.007	1.009	1.022
0.03	0.10	0.630	1.007	1.009	1.026
0.05	0.00	0.222	1.001	1.019	1.002
0.05	0.02	0.230	1.005	1.016	1.004
0.05	0.04	0.334	1.008	1.015	1.009
0.05	0.06	0.430	1.009	1.015	1.014
0.05	0.08	0.485	1.010	1.016	1.019
0.05	0.10	0.515	1.010	1.017	1.023

Notes: Private sector gain used to combine forecasts is 0.03. Responsiveness of the output gap to the inflation gap is 0.60.

Table 6: Central bank publishes inflation forecasts: Effect of varying κ^f and κ^{cb}.

κ^f	κ^{cb}	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.01	0.00	0.189	0.999	1.011	0.999
0.01	0.02	0.276	1.003	1.008	1.004
0.01	0.04	0.544	1.006	1.007	1.011
0.01	0.06	0.645	1.006	1.008	1.018
0.01	0.08	0.676	1.006	1.008	1.024
0.01	0.10	0.695	1.006	1.008	1.028
0.03	0.00	0.250	1.000	1.010	1.001
0.03	0.02	0.312	1.004	1.007	1.004
0.03	0.04	0.498	1.006	1.008	1.011
0.03	0.06	0.582	1.007	1.008	1.017
0.03	0.08	0.610	1.007	1.009	1.022
0.03	0.10	0.630	1.007	1.009	1.026
0.05	0.00	0.275	1.001	1.010	1.002
0.05	0.02	0.323	1.004	1.008	1.004
0.05	0.04	0.476	1.006	1.008	1.011
0.05	0.06	0.550	1.007	1.009	1.016
0.05	0.08	0.578	1.007	1.010	1.021
0.05	0.10	0.597	1.008	1.010	1.025

Notes: Private sector gain used to estimate AR(1) model is 0.03. Responsiveness of the output gap to the inflation gap is 0.60.

5.3.3 Communication strategies

Table 7: Central bank communicates inflation target only.

$RMSE_{\pi^{e}_{t\|t-1}}$	$RMSE_{\pi^{v}_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
1.002	1.002	1.002

Notes: Central bank gain is equal to 0. Private sector gain used to estimate AR(1) model is 0.03. Responsiveness of the output gap to the inflation gap is 0.60.

Table 8: Central bank communicates inflation target and inflation forecasts: Effects of varying κ^{cb}.

κ^{cb}	$\bar{\gamma}_t$	$RMSE_{\pi^{v}_{t\|t-1}}$	$RMSE_{\pi^{v}_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.254	1.000	1.003	1.000
0.02	0.552	1.002	1.002	1.003
0.04	0.705	1.004	1.003	1.011
0.06	0.720	1.004	1.003	1.018
0.08	0.721	1.004	1.004	1.023
0.10	0.723	1.004	1.004	1.027

Notes: Private sector gain is equal to 0.03. Responsiveness of the output gap to the inflation gap is 0.60.

5.3.4 Sensitivity analysis

Changing the structure of the economy

Table 9: Perfect knowledge benchmark: Effect of varying θ.

θ	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.40	0.998	0.998	0.998
0.83	0.998	0.998	0.998

Notes: Central bank and private sector both know all parameters of the model.

Table 10: Central bank does not communicate any information: Effect of varying θ.

θ	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.40	1.006	1.006	1.006
0.83	1.006	1.006	1.006

Notes: Central bank gain is equal to 0. Private sector gain used to estimate AR(1) model is 0.03.

Table 11: Central bank publishes inflation forecasts: θ=0.40.

κ^{cb}	θ	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.40	0.246	1.000	1.010	1.001
0.02	0.40	0.315	1.004	1.008	1.004
0.04	0.40	0.463	1.005	1.008	1.009
0.06	0.40	0.521	1.006	1.009	1.013
0.08	0.40	0.540	1.006	1.009	1.015
0.10	0.40	0.557	1.006	1.010	1.018

Notes: Private sector gains are equal to 0.03. Responsiveness of the output gap to the inflation gap is 0.40.

Table 12: Central bank publishes inflation forecasts: θ=0.83.

κ^{cb}	θ	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.83	0.251	1.000	1.010	1.001
0.02	0.83	0.307	1.004	1.008	1.004
0.04	0.83	0.504	1.007	1.007	1.012
0.06	0.83	0.609	1.008	1.008	1.020
0.08	0.83	0.650	1.008	1.009	1.027
0.10	0.83	0.672	1.008	1.009	1.034

Notes: Private sector gains are equal to 0.03. Responsiveness of the output gap to the inflation gap is 0.83.

Table 13: Central bank communicates inflation target only: Effect of varying θ.

θ	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.40	1.002	1.002	1.002
0.83	1.002	1.002	1.002

Notes: Central bank gain is equal to 0. Private sector gain used to estimate AR(1) model is 0.03.

Table 14: Central bank communicates inflation target and inflation forecasts: θ=0.40.

κ^{cb}	θ	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.40	0.253	1.000	1.003	1.000
0.02	0.40	0.531	1.002	1.002	1.003
0.04	0.40	0.653	1.003	1.003	1.009
0.06	0.40	0.653	1.003	1.004	1.013
0.08	0.40	0.654	1.004	1.004	1.015
0.10	0.40	0.666	1.004	1.004	1.018

Notes: Private sector gains are equal to 0.03. Responsiveness of the output gap to the inflation gap is 0.40.

Table 15: Central bank communicates inflation target and inflation forecasts: θ=0.83.

κ^{cb}	θ	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.83	0.256	1.000	1.003	1.000
0.02	0.83	0.559	1.002	1.002	1.003
0.04	0.83	0.724	1.004	1.002	1.011
0.06	0.83	0.756	1.005	1.003	1.020
0.08	0.83	0.759	1.005	1.004	1.028
0.10	0.83	0.759	1.005	1.004	1.035

Notes: Private sector gains are equal to 0.03. Responsiveness of the output gap to the inflation gap is 0.83.

Changing the private sector gain

Table 16: Central bank publishes inflation forecasts: κ^v=κ^f=0.01.

κ^{cb}	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.247	0.999	1.002	0.999
0.02	0.698	1.001	1.001	1.006
0.04	0.787	1.001	1.002	1.018
0.06	0.805	1.001	1.002	1.026
0.08	0.808	1.001	1.002	1.031
0.10	0.811	1.001	1.002	1.035

Notes: Private sector gains are equal to 0.01. Responsiveness of the output gap to the inflation gap is 0.60.

Table 17: Central bank communicates inflation target and inflation forecasts: κ^v=κ^f=0.01.

κ^{cb}	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.247	0.998	1.000	0.999
0.02	0.811	1.000	1.000	1.007
0.04	0.839	1.000	1.000	1.018
0.06	0.845	1.000	1.000	1.027
0.08	0.841	1.000	1.000	1.032
0.10	0.841	1.000	1.000	1.035

Notes: Private sector gains are equal to 0.01. Responsiveness of the output gap to the inflation gap is 0.60.

Table 18: Central bank publishes inflation forecasts: κ^v=κ^f=0.10.

κ^{cb}	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.257	1.008	1.042	1.009
0.02	0.254	1.011	1.039	1.007
0.04	0.271	1.014	1.038	1.009
0.06	0.299	1.015	1.038	1.013
0.08	0.328	1.016	1.039	1.017
0.10	0.350	1.017	1.039	1.019

Notes: Private sector gains are equal to 0.10. Responsiveness of the output gap to the inflation gap is 0.60.

Table 19: Central bank communicates inflation target and inflation forecasts: κ^v=κ^f=0.10.

κ^{cb}	$\bar{\gamma}_t$	$RMSE_{\pi^e_{t\|t-1}}$	$RMSE_{\pi^v_{t\|t-1}}$	$RMSE_{\pi^{cb}_{t\|t-1}}$
0.00	0.264	1.006	1.020	1.008
0.02	0.253	1.009	1.018	1.003
0.04	0.315	1.011	1.018	1.005
0.06	0.401	1.012	1.018	1.009
0.08	0.446	1.012	1.018	1.013
0.10	0.473	1.013	1.019	1.016

Notes: Private sector gains are equal to 0.10. Responsiveness of the output gap to the inflation gap is 0.60.