Imperfect Central Bank Communication: Information versus Distraction*

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Abstract

This paper considers the potential benefits and limitations of central bank communications in a model of imperfect knowledge and learning. Much of the information communicated by central banks is noisy or imperfect. Interpreted correctly, such information can inform and improve private-sector decisions and expectations, but it also has the potential to mislead and distract. As in Morris and Shin (2002), the value of communicating imperfect information is shown to be ambiguous and depends on the relative precision of central bank and private sector information. But the mechansim giving rise to this ambiguity is different to that of Morris and Shin and stems from the inability of the private sector to assess the quality of imperfect central bank communications. The role of imperfect communication is also analysed in the context of communication strategies which comprise numerous types of information that can be communicated. Central banks may prefer to focus their communication policies on the information they know most about. Indeed, communicating more certain information may "crowd 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 The cultivation of secrecy and mystique has been replaced by a zeal for openness and transparency.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. Many central banks provide information about their long-run objectives by announcing quantified targets for inflation. Similarly, central banks in increasing numbers supply detailed information regarding their analysis of the outlook for the economy, often in the form of numerical forecasts of inflation and economic activity. Some central banks also convey qualitative guidance regarding the likely direction of future policy, and a few even offer quantitative projections of their policy rate.

In practice, both central banks and the public have imperfect knowledge about the structure of the economy and the shocks affecting the economy. 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 rationalize 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] Recognizing the private sector's imperfect knowledge means central bank communications have the potential to aid private sector learning. Moreover, the limits on central banks' knowledge and understanding means that much of the information communicated by central banks is uncertain or imperfect, such as economic forecasts and 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 mislead and result in worse economic outcomes.[2]

[1] In a similar vein, Ben Bernanke, Chairman of the Federeal 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).

[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).

Imperfect central bank communication is a doubled-edged sword that should be used with care.

This paper considers the role of central bank communication in an environment of imperfect knowledge and learning. The benefits and limitations of imperfect communications are analyzed in a model in which 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 role of imperfect central bank communication 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 forecasts, publishing the forecasts improves the accuracy of private-sector expectations. This is the case irrespective of the quality of the central bank's forecasts: The gains from combining multiple forecasts means that the private sector benefits from the publication of central bank forecasts even if the forecasts are less precise than its own. 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 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. The likelihood that the publication of central bank forecasts will mislead the private sector in this way depends on the relative precision of the central bank and private sector forecasts. As the relative precision of the central bank's forecasts decline, there is a greater chance that publishing these forecasts will lead to worse outcomes.

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. In MS, 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.[3] In the model considered here, the possibility that the private

[3] See Svensson (2006) and Morris *et al.*(2006) for a discussion of the quantitative significance of this result.

sector may attach the incorrect weight to public information stems from the private sector's imperfect ability to assess the quality of such information. Relative to an environment in which it is able to assess perfectly the quality of the information conveyed by the central bank, the private sector may place too little or too much weight on that information. If the private sector attaches "too little" weight, imperfect communication by the central bank still helps to inform private-sector expectations, but not by as much as it potentially could do. In contrast, if the private sector places "too much" weight on the central bank's imperfect communications, they have the potential to detract from the accuracy of its expectations. If the information communicated by the central bank is too noisy relative to the private sector's existing uncertainty, it may be better for the central bank not to communicate that information.

In practice, central bank's communication strategies do not take the form of a binary decision of whether or not to publish economic forecasts. Central banks have a range of information at their disposal that they can potentially communicate to help inform private-sector expectations. The design challenge faced by central banks is how best to use that information to aid the functioning of the economy and the effectiveness of policy. Importantly, there is a considerable range of uncertainty associated with different types of central bank information. 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 private sector may be unable to assess correctly the quality of the information it communicates means that central banks may prefer to communicate more certain information. Indeed, communicating more certain information may "crowd out" a role for communicating imperfect information. That is, it may improve the private sector's understanding of the economy to a point at which it is no longer beneficial for the central bank to run the risk of communicating imperfect information. The possibility that communicating more certain information may "crowd out" imperfect communication in this way is explored by considering a case in which the central bank is able to announce its inflation objective as well as publish its economic forecasts.

The remainder of this paper is organized as follows: Section two 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 for inflation. The central bank is assumed to use a structural model of the economy to estimate the parameters 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 the equilibrium dynamics that would prevail under a rational-expectations equilibrium with perfect knowledge. The central bank and private sector update their model coefficients recursively 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. 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

[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] Equivalent 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.

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

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. 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

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

where π_t is inflation, $\pi^e_{t|t-1}$ is the private sector expectation of time t inflation formed at $t-1$, y_t is the output gap and e_t is a disturbance with properties $e_t \sim iid\left(0, \sigma_e^2\right)$. The output gap is given by

$$y_t = x_t + u_t, \tag{2}$$

where x_t is the intended output gap and u_t is a disturbance with properties $u_t \sim iid\left(0, \sigma_u^2\right)$. The intended output gap for period t is determined by the central bank in period $t-1$ according to its reaction function as

$$x_t = -\theta\left(\pi_{t-1} - \pi^*\right), \tag{3}$$

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 1. In phase (i), the output gap and inflation in period t are determined, and inflation is observed by the central bank and private sector. The output gap is not observed by either the central bank or the 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 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 intended output gap) for the next period.

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

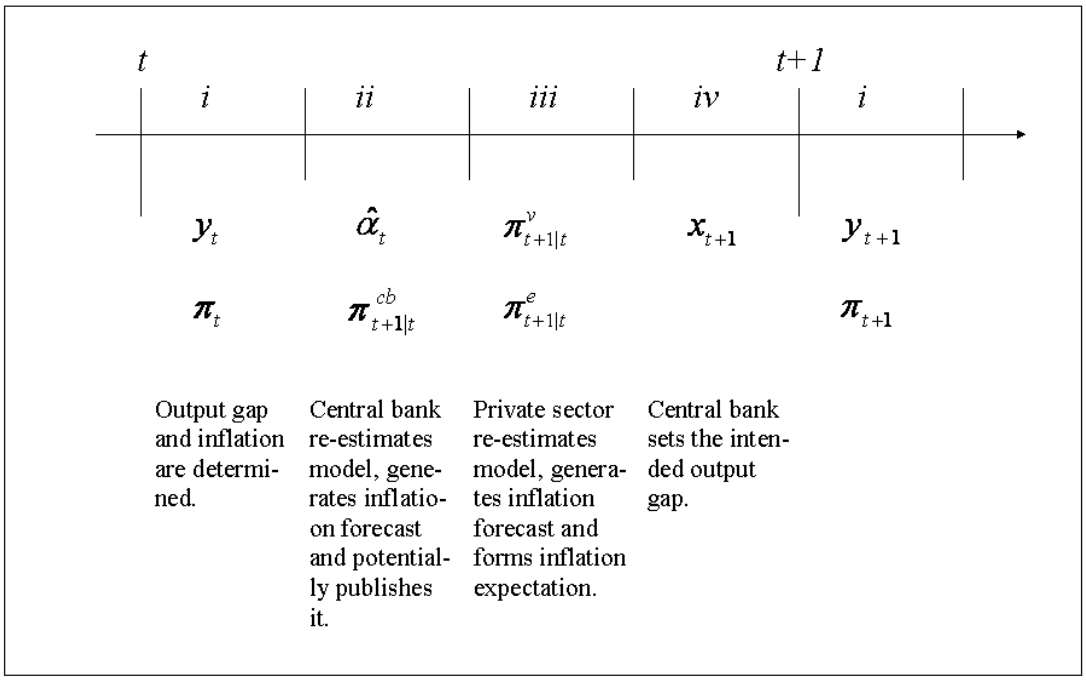

Figure 1: The timing of the model.

imperfect knowledge, 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. The central bank therefore recursively estimates α each period using constant gain least squares according to

$$\pi_t - \phi\pi^e_{t|t-1} - (1-\phi)\,\pi_{t-1} = \alpha_t x_t + \psi_t. \tag{4}$$

The regression coefficient α_t can be written as

$$\hat{\alpha}_t = \hat{\alpha}_{t-1} + \kappa^{cb}\left(R^{cb}_t\right)^{-1} x_t\left(\pi_t - \phi\pi^e_{t|t-1} - (1-\phi)\,\pi_{t-1} - \hat{\alpha}_{t-1}x_t\right), \tag{5}$$

where

$$R^{cb}_t = R^{cb}_{t-1} + \kappa^{cb}\left(x^2_t - R^{cb}_{t-1}\right) \tag{6}$$

and κ^{cb} is the gain.[7]

The central bank's inflation forecast is given by

$$\pi^{cb}_{t+1|t} = \frac{\hat{\alpha}_t\theta}{1-\phi}\pi^* + \frac{1-\phi-\hat{\alpha}_t\theta}{1-\phi}\pi_t, \tag{7}$$

where this forecast assumes that private-sector inflation expectations are formed according to the reduced-form relationship that would be the solution under full information and

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

rational expectations.[8]

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

$$\pi_t = c_{0,t} + c_{1,t}\pi_{t-1} + v_t \tag{8}$$

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

$$\hat{c}_t = \hat{c}_{t-1} + \kappa^v R_t^{-1} X_t \left(\pi_t - X_t' \hat{c}_{t-1}\right) \tag{9}$$

where

$$R_t = R_{t-1} + \kappa^v \left(X_t X_t' - R_{t-1}\right), \tag{10}$$

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

The model in equation (8) is then used to generate a model-based forecast for inflation according to

$$\pi^v_{t+1|t} = \hat{c}_{0,t} + \hat{c}_{1,t}\pi_t. \tag{11}$$

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 (11) with the central bank's according to

$$\pi^e_{t+1|t} = \gamma_t \pi^v_{t+1|t} + (1 - \gamma_t)\, \pi^{cb}_{t+1|t}. \tag{12}$$

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

$$\pi_t - \pi^{cb}_t = g_t \left(\pi^v_{t|t-1} - \pi^{cb}_t\right) + \chi_t \tag{13}$$

[8] 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 qualitative results discussed here.

using recursive least squares; the gain in this procedure is denoted κ^f.[9] 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.[10] 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 consider the role of central bank forecasts and show how 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. Finally, we consider the case in which the central bank has the ability to announce its inflation target as well as publish its inflation forecast, and show how announcing an inflation target may "crowd out" the 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 terms have variance $\sigma_e^2 = 1$ and $\sigma_u^2 = 0$. The responsiveness of monetary policy (in the form of the intended output gap) to the inflation gap is set to $\theta = 0.6$.[11] The gains used by the private sector in equations (8) and (13) are set to

[9] 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.

[10] This intermediate case – in which the central bank is assumed to have perfect knowledge and uses communication polices to overcome private sector information imperfections – is more typical of the approach followed in much of the literature on central bank communications; see, for example, Brazier *et al.* (2006) and Rudebusch and Williams (2006).

[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 $\mathcal{L} = \omega Var\left(\pi_t - \pi^*\right) +$

$\kappa^v = \kappa^f = 0.03$.[12] The effectiveness of central bank communication is evaluated by the accuracy of private sector inflation expectations, measured by their RMSE. 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.[13] 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 in this case is governed by the variance of the shocks affecting the economy.[14]

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.

$(1-\omega)\,Var\,(y_t)$ 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] Where t denotes the distance in time between the observation being weighted and the current observation.

[14] The RMSEs are very close to the true value of σ_e^2. The deviation is due to random error – this has been established by choosing different random number seeds.

3.2.1 A quiet central bank

Suppose the central bank choose not to publish its forecast. Given our setup, the private sector has no information other than its own least squares forecasts from equation (11) and its inflation expectations are simply given as $\pi^e_{t+1|t} = \pi^v_{t+1|t}$. 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 deteriorates.

3.2.2 The central bank communicates forecasts only

Consider now the case in which the central bank chooses to communicate its forecasts to the private sector. The private sector now needs to recursively update estimates of both its forecast model (8) 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 calculate the weight to attach to the central bank's forecast $(1 - \gamma_t)$.[15] 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 so the precision of its inflation expectations correspondingly improve.

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. 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

[15] For simplicity, the gain used by the private sector to estimate its forecasting model (8) is held constant at $\kappa^v = 0.03$.

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.

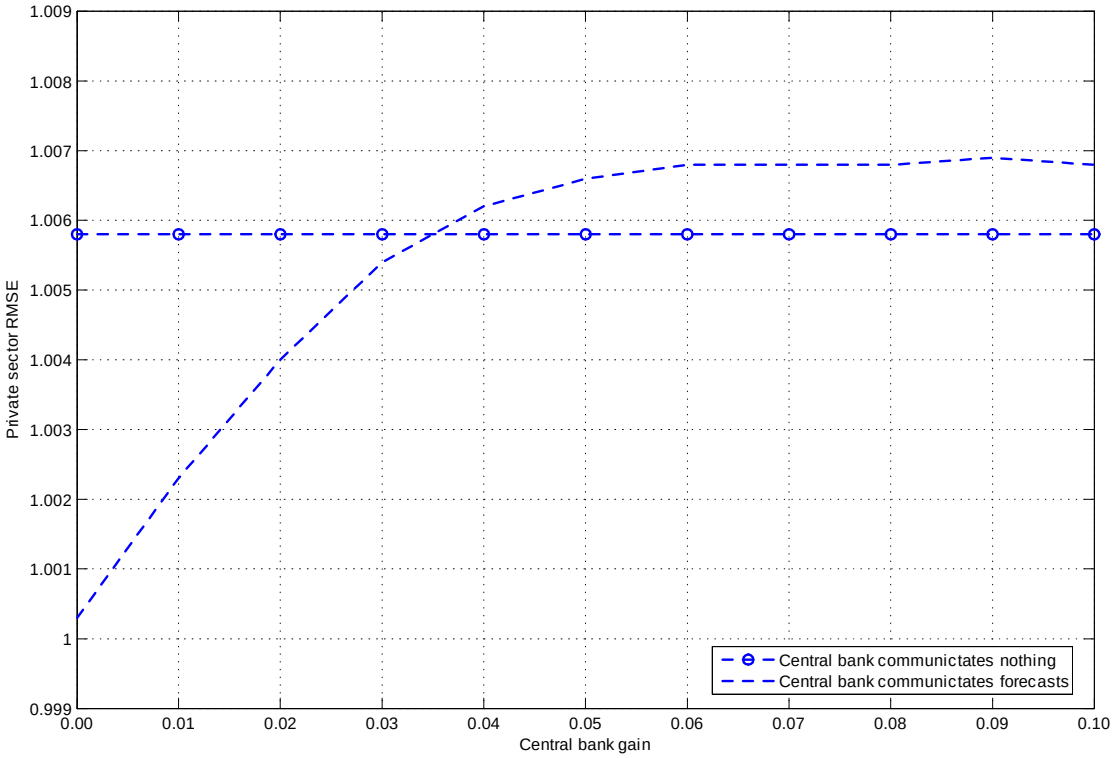

Figure 2: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.60$. $T = 160\ 000$.

The effect of publishing central bank forecasts on the RMSE of private-sector expectations is shown Figure 2.[16] As before, the private sector is assumed to update its forecasting equation (8) each period using constant 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 of 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

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

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 always learning 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 be harmful to the accuracy of private-sector expectations depends 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. 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: $\kappa^v = (0.01,\ 0.03,\ 0.05)$).[17] As the precision of private sector forecasts improves – that is, the value of κ^v declines – the minimum level of accuracy at which it stops being beneficial for the central bank to publish its forecasts declines.[18] 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.[19] As the ability of the private sector to assess the quality of central bank forecasts falls – that

[17] 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.

[18] 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 $\kappa^{cb} = 0.1$.

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

is, κ^f rises – it becomes increasingly likely that publishing noisy economic forecasts may distract the private sector.

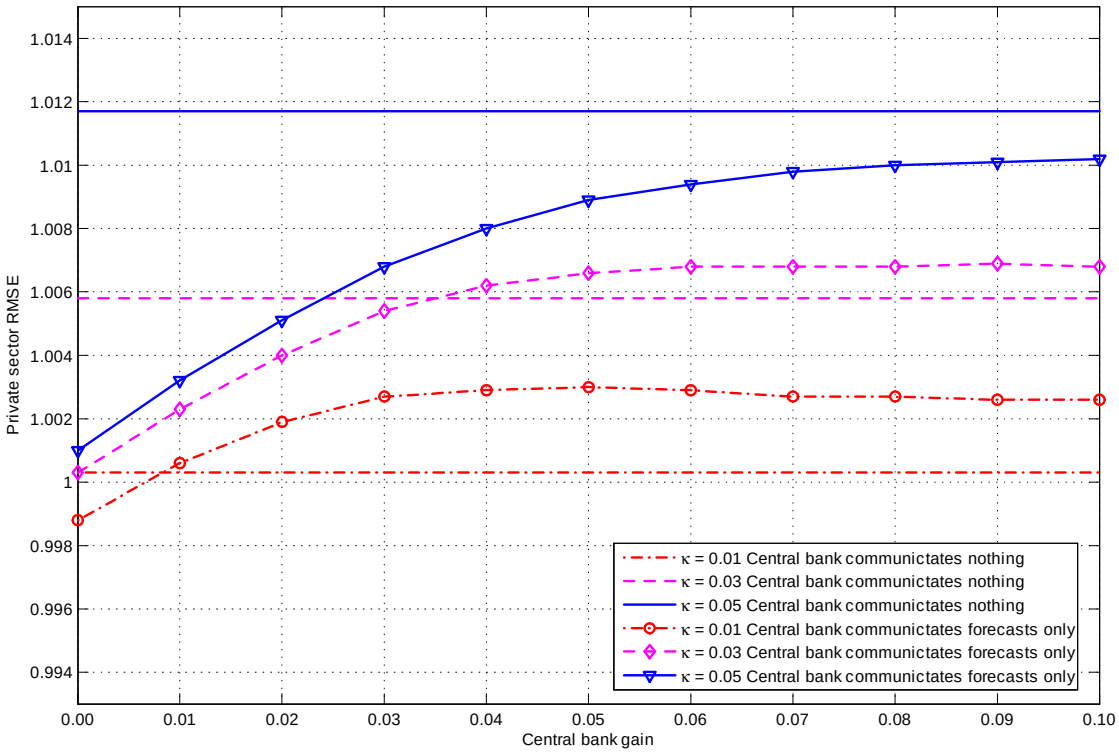

Figure 3: Private sector RMSEs under different communicaiton strategies. Private sector gain used to combine forecasts is 0.03. $\theta = 0.60$. $T = 160\ 000$.

The results discussed so far have stressed the *qualitative* implications of the model: Namely, the benefits of a central bank communicating imperfect information decline as the information being conveyed becomes less precise and as the ability of the private sector to assess the quality of that information deteriorates. 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 perhaps 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

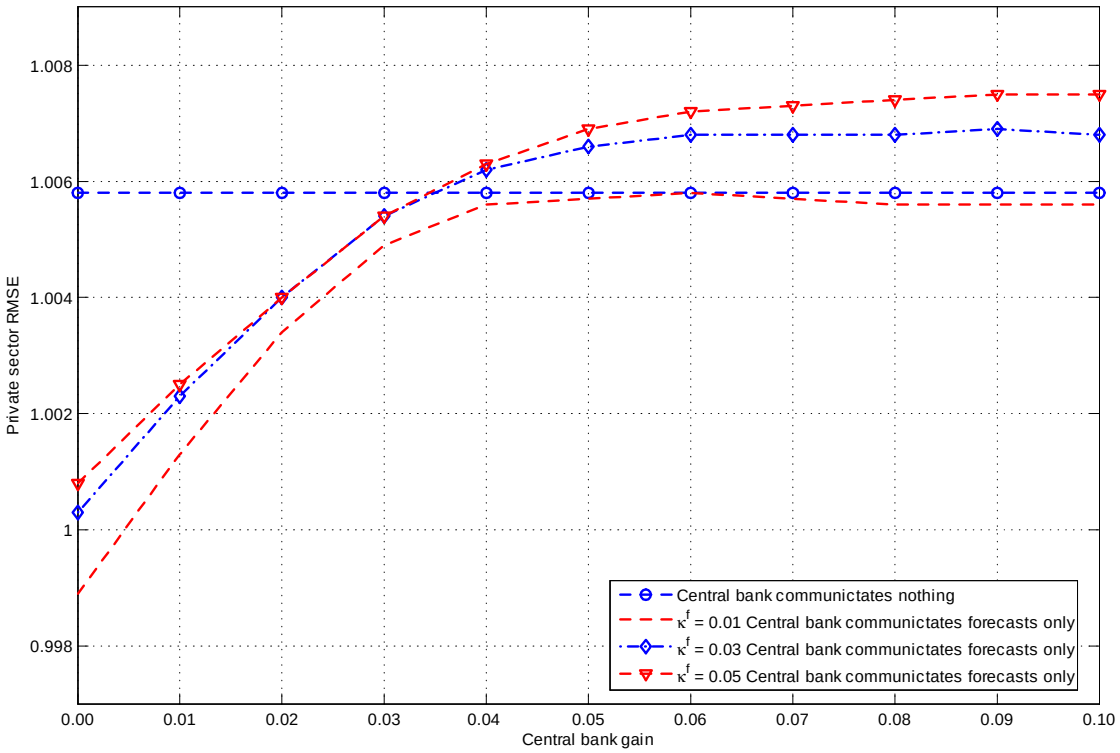

Figure 4: Private sector RMSEs under different communicaiton strategies. Private sector gain used to estimate AR(1) model is 0.03. $\theta = 0.60$. $T = 160\ 000$.

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.

3.4 Communication strategies

So far we have assumed that the central bank has only one type 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 central banks have a wide range of information at their disposal that might help inform private-sector expectations, e.g. its inflation target, minutes of policy meetings, near-term policy guidance, economic reports, speeches etc. All central banks communicate some information. The challenge faced by central banks is to design a communications strategy that combines various types of information in a way that helps

to inform private-sector expectations in an efficient and effective manner. Importantly, the uncertainty attached to this information is likely to vary across information types: For example, the information a central bank can communicate about its inflation target is likely to be less uncertain than its economic forecasts. Given the risk that the private sector may be unable to assess correctly the information communicated by the central bank, the central bank where possible may prefer to communicate more certain (less imperfect) information. These issues can be explored 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.[20] It can accordingly estimate the restricted model

$$\pi_t - \pi^* = c_{1,t}\left(\pi_{t-1} - \pi^*\right) + v_t \tag{14}$$

and forecasts based on this least squares estimation are generated as

$$\pi^v_{t+1|t} = \left(1 - \hat{c}_{1,t}\right)\pi^* + \hat{c}_{1,t}\pi_t. \tag{15}$$

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.[21] 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 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 only publishes its inflation forecasts. The lower two [red] lines illustrate the effect of communication strategies which involve announcing an inflation target. The horizontal red line shows the case in which the central bank only announces its inflation target and the upward-sloping red line considers the outcome of a communications strategy in which the central bank both announces its inflation target and publishes its inflation forecasts.

A number of points can be highlighted from Figure 5. First, the communication strategies which include the announcement of an inflation target are unambiguously better than

[20] For simplicity, we assume that that the announcement of the inflation target is perfectly credible. Allowing for the possibility of imperfect credibility would not affect the qualitative results; results are not reported but are available upon request.

[21] Results are also shown in Tables 6 to 8.

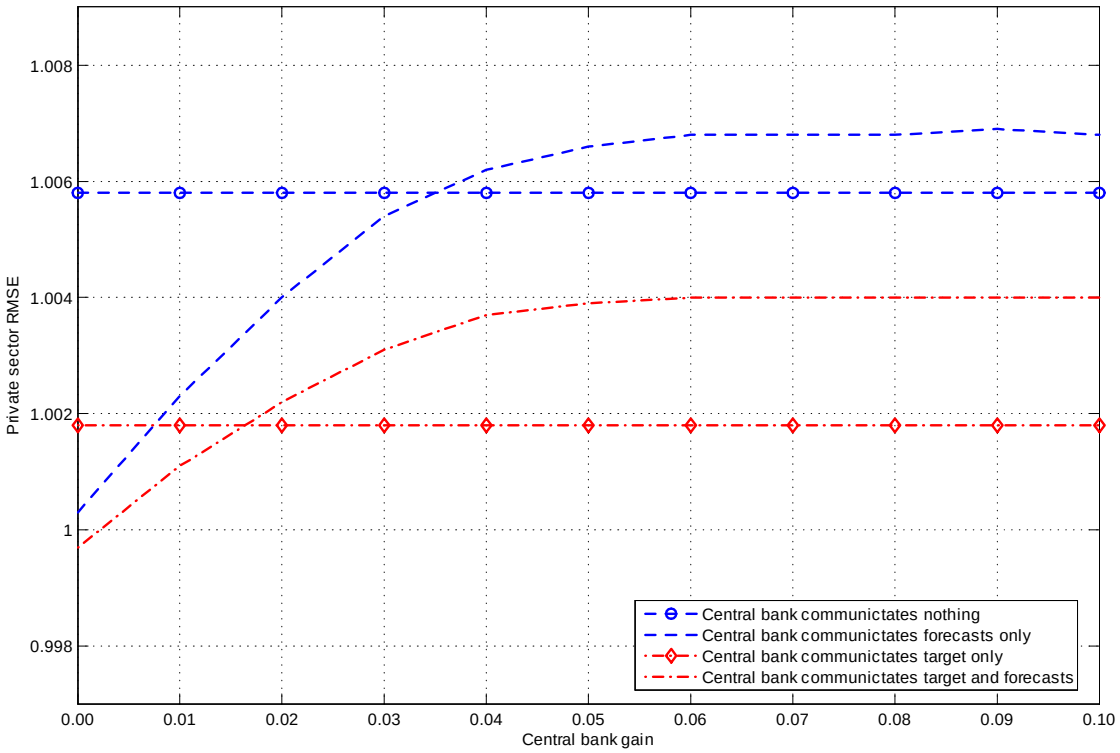

Figure 5: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.60$. $T = 160\ 000$.

those which do not. Importantly, communicating certain information, such as an inflation target, means there is no risk that the private sector will place too much weight on that information.[22]

Second, 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 – proxied here by the value of the central bank's gain κ^{cb} increasing beyond a certain point – it is better for the central bank to only announce its inflation target, rather than to also publish its inflation forecast.

Finally, announcing an inflation target means that the standards of accuracy required

[22] 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.

for it to be beneficial for the central bank to also publish its inflation forecasts are more strenuous. This can be seen in Figure 5 by the fact that the level of central bank gain κ^{cb} at which it is no longer beneficial for the central bank to publish its inflation forecasts is lower – the minimum level of accuracy of the central bank's forecast is higher – in the case in which the central bank announces an inflation target than in the case in which it does not. The intuition for this result stems directly from the observation that the benefit of publishing the central bank's forecasts depends on the 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 makes it less beneficial for it to publish its own inflation forecasts. 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.

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 that so many central banks today are actively engaged in processes and reviews to improve further their communications suggests there is further to go. 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. Recognizing 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. 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. But 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 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 uncertainty 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 and 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 very stylized and the results should not be interpreted as literally suggesting that publishing central bank inflation forecasts is, as a practical matter, likely to mislead the general public. Indeed, the fact that since the US Federal Reserve became the first central bank to publish its economic projection in 1979, central banks in every advance economy have moved to publish some form of economic forecast suggests that experience has led central banks to conclude that publishing economic forecasts for inflation 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 path of their policy rate.[23]

The suggestion that central banks should focus their communications on information they know most about is most apt in the design of central bank communication strategies which comprise numerous types of information which could potentially be announced or published. The assertion that central banks should publish ever increasing amounts of information needs to be evaluated in the context of the information that is already being communicated and the extent of the public's understanding. The communication of more certain information may "crowd out" a role for communicating imperfect information.

[23] For example, the difficulty of communicating highly imperfect information and the risk that it may be interpreted incorrectly, appears to underlie some of Governor Mervyn King's concerns about the Bank of England publishing an interest rate path: "*We don't say where interest rates will go for the simple reason we don't know. And it would be quite misleading to pretend otherwise. .... [T]rying to give direct hints on the path of interest rates over the next few months risks deceiving financial markets into believing there are definite plans for the next few months when no such plans exist*" (King, 2006)

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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 intended output gap to the inflation gap, that is, the value of θ.[24] 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 full information and for the no communication cases 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.[25]

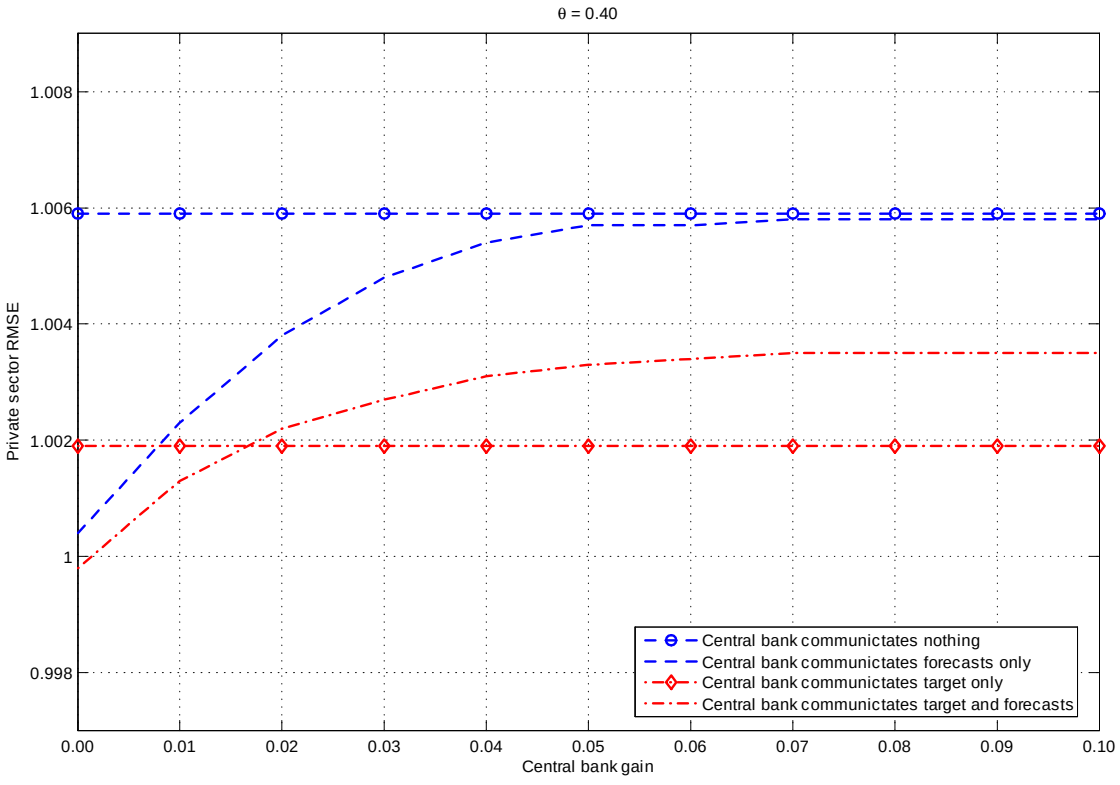

Figure 6: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.40$. $T = 160\ 000$.

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

[25] 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 intended 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.

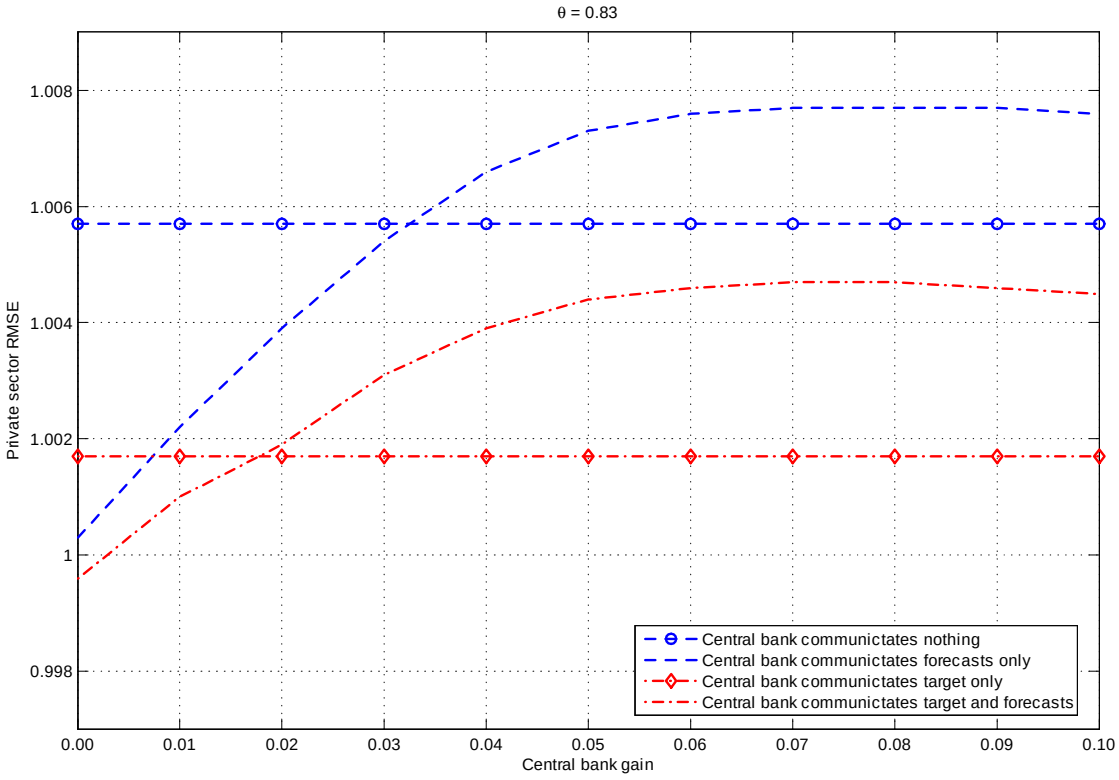

Figure 7: Private sector RMSEs under different communicaiton strategies. Private sector gains are equal to 0.03. $\theta = 0.83$. $T = 160\ 000$.

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.[26] Results are reported in Figures 8 and 9, and Tables 16 to 19.

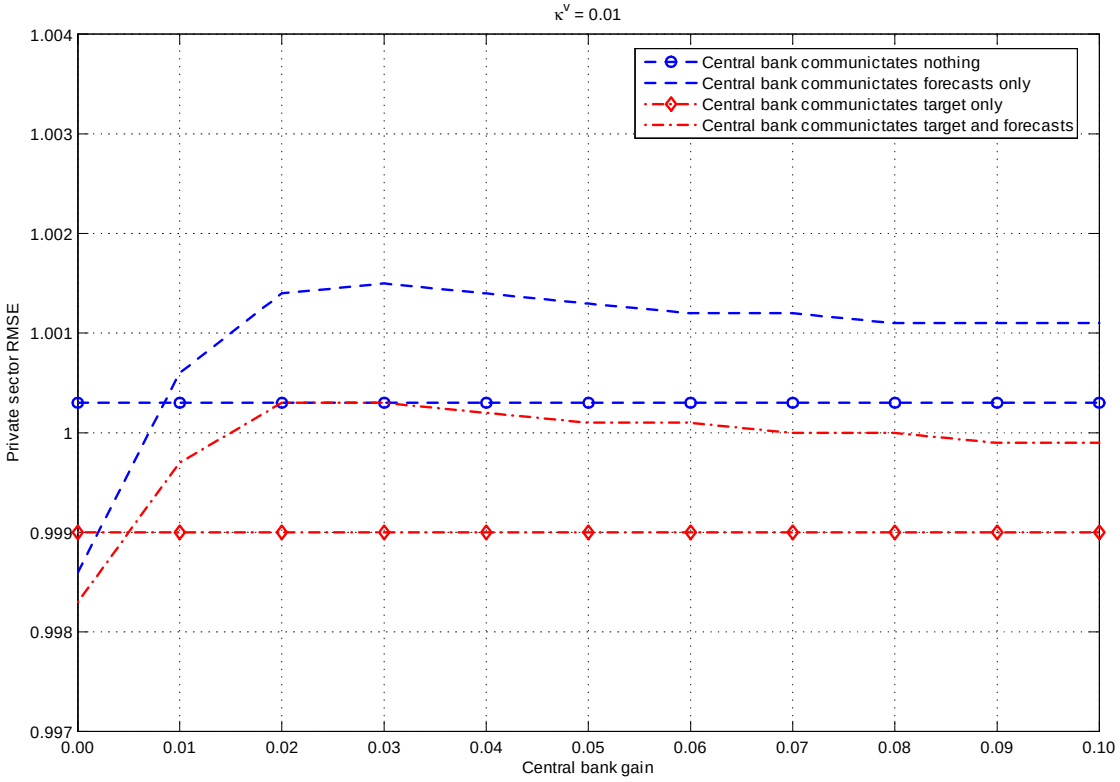

Figure 8: Private sector RMSEs under different communication strategies. Private sector gains are equal to 0.01. $\theta = 0.60$. $T = 160\ 000$.

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. Similarly, 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.

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

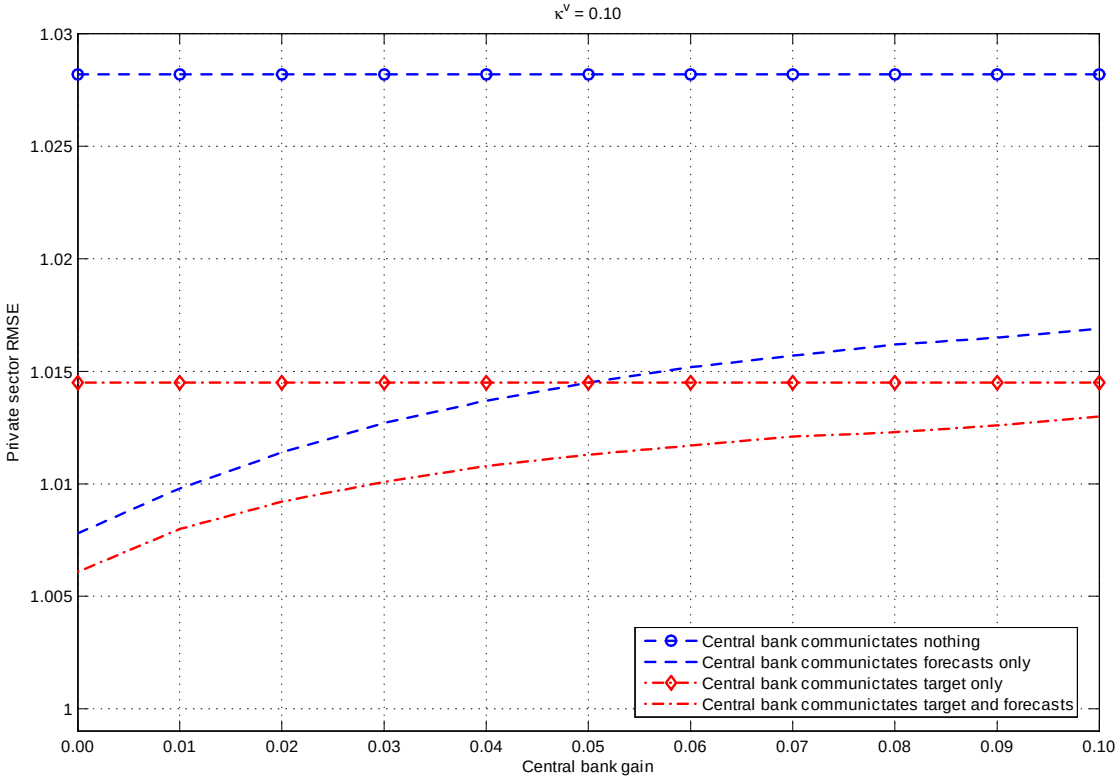

Figure 9: Private sector RMSEs under different communication strategies. Private sector gains are equal to 0.10. $\theta = 0.60$. $T = 160\ 000$.

5.3 Tables

Table 1: Full information rational expectations.

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

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

Table 2: No central bank communication.

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 intended output gap to the inflation is 0.60.

Table 3: Central bank communicates only 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 intended output gap to the inflation is 0.60.

Table 4: Central bank communicates inflation forecasts only.

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 intended output gap to the inflation is 0.60.

Table 5: Central bank communicates forecasts only.

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	1.000	1.000	1.000	1.000
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	1.000	1.006	1.006	1.006
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	1.000	1.012	1.012	1.012
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 intended output gap to the inflation is 0.60.

Table 6: Central bank communicates forecasts only.

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	1.000	1.006	1.006	1.006
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	1.000	1.006	1.006	1.006
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	1.000	1.006	1.006	1.006
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 intended output gap to the inflation is 0.60.

Table 7: Central bank communicates the 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 intended output gap to the inflation is 0.60.

Table 8: Central bank communicates forecasts and target.

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	1.000	1.002	1.002	1.002
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 intended output gap to the inflation is 0.60.

Table 9: Full information rational expectations.

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: No central bank communication.

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 communicates the inflation target only.

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 12: Central bank communicates forecasts only.

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	1.000	1.006	1.006	1.006
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 intended output gap to the inflation is 0.40.

Table 13: Central bank communicates forecasts and the inflation target.

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	1.000	1.002	1.002	1.002
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 intended output gap to the inflation is 0.40.

Table 14: Central bank communicates forecasts only.

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	1.000	1.006	1.006	1.006
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 intended output gap to the inflation is 0.83.

Table 15: Central bank communicates forecasts and the inflation target.

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	1.000	1.002	1.002	1.002
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 intended output gap to the inflation is 0.83.

Table 16: Central bank communicates forecasts only.

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	1.000	1.000	1.000	1.000
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 intended output gap to the inflation is 0.60.

Table 17: Central bank communicates forecasts and the inflation target.

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	1.000	0.999	0.999	0.999
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 intended output gap to the inflation is 0.60.

Table 18: Central bank communicates forecasts only.

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	1.000	1.028	1.028	1.029
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 intended output gap to the inflation is 0.60.

Table 19: Central bank communicates forecasts and the inflation target.

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	1.000	1.015	1.015	1.016
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 intended output gap to the inflation is 0.60.