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Observing and shaping the market: the dilemma of central banks

Romain Baeriswyl, Camille Cornand, Bruno Ziliotto

Abstract:

While the central bank observes the market activity to assess economic fundamentals, it shapes the market outcome through its policy interventions. The more the central bank influences the market, the more it spoils the informational content of economic aggregates. How should the central bank act and communicate when it derives its information from observing the market? This paper analyses the optimal central bank's action and disclosure under endogenous central bank's information for three operational frameworks: pure communication, action and communication, and signaling action. When the central bank takes an action, it would be optimal for the central bank to be fully opaque to prevent its disclosure from deteriorating the information quality of market outcomes. However, in the realistic case where central bank's action is observable, it may be optimal to refrain from implementing any action.

Keywords:

heterogeneous information, public information, endogenous information, overreaction, transparency, coordination.

JEL codes:

D82, E52, E58

Observing and shaping the market: the dilemma of central banks*

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October 20, 2017

Abstract

While the central bank observes the market activity to assess economic fundamentals, it shapes the market outcome through the conduct of monetary policy. A dilemma arises from this dual role because the more the central bank shapes the market, the more it spoils the informational content of market prices.

This paper analyses the optimal monetary policy action and disclosure under endogenous central bank's information for three operational frameworks: pure communication, action and communication, and signaling action. Taking the endogenous nature of central bank's information into account calls for less activism from the central bank.

JEL classification: D82, E52, E58.

Keywords: heterogeneous information, public information, endogenous information, overreaction, transparency, coordination.

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1 Introduction

To conduct monetary policy, the central bank observes market outcomes to glean information on the state of the economy. At the same time, the central bank shapes the economy through the conduct of monetary policy by taking actions and disclosing statements. This paper analyses optimal monetary policy when the central bank observes the market to assess economic fundamentals.

A growing literature addresses the issue of central banks' communication in coordination games with heterogenous information. Morris and Shin (2002) (henceforth MS) present a Keynesian beauty contest game where the equilibrium behaviour of economic agents is driven by both a fundamental and a coordination motive. The focal role that public information exerts on higher order beliefs of agents gives rise to an overreaction, which may be detrimental to welfare. If public information is poorly accurate, it may distort the market outcome away from the economic fundamental. While MS refer to the case where the provider of public information only considers the possibility of disclosing information, further works have applied the beauty contest mechanism to more realistic and complex environments. These extensions can be classified along two lines.

First, the beauty contest game has been extended by allowing the provider of public information to take an action, as central banks do in reality. James and Lawler (2011) analyse the optimal disclosure strategy when the central bank also takes an action and find that full opacity is optimal. Indeed, by taking an hidden action, the central bank succeeds in stabilising the economy without creating overreaction to any disclosure.¹ However, Baeriswyl and Cornand (2010) state that taking an action inevitably provides public information as it signals the central bank's belief to agents, qualifying the possibility of taking an action under opacity.²

Second, the beauty contest game has been applied to the case where the provider of public information collects its own information about economic fundamentals from observing the economic outcome, rather than from directly observing fundamentals. In the model of MS, central bank's information is exogenous in the sense that it is independent of the existence and behaviour of the market. However, the central bank usually assesses the state of the economy by observing market outcomes because there is not such a thing as an observable fundamental in reality. Market prices are not only exchange ratios between goods but also aggregators of information, as underlined by Hayek (1945). Prices play an informational role by aggregating agents' knowledge and beliefs about the state of the economy. Yet, market prices (and especially financial prices) are influenced by the central bank itself. The central bank is thus both an observer and a shaper of the market outcome.

The ambivalent role of the central bank causes a dilemma with respect to the imple-

¹Angeletos et al. (2016) also study the welfare consequences of public disclosures in micro-founded business cycle model.

²There is a large literature that focuses on the interrelation between central bank transparency and stabilisation policy as e.g. Cukierman and Meltzer (1986) and Faust and Svensson (2001). However, the framework here is different as it is characterised by heterogenous information and central bank's information is not perfect.

mentation of monetary policy, which has been documented by Amato and Shin (2006) and Morris and Shin (2005): the more successfully a central bank influences market expectations, the less reliable market outcomes serve as indicators of the fundamental of the economy. Baeriswyl (2011) extends the model of MS to the case where the central bank observes the economic outcome to draw its information about the fundamental (endogenous information). He shows that while a higher degree of transparency strengthens the influence of the central bank on agents' decision, it deteriorates the accuracy of its information, making transparency less desirable. Central bank's endogenous information therefore represents an additional argument challenging the presumed benefit of central bank's transparency. As in MS, Baeriswyl (2011) only considers the possibility for the central bank of disclosing information.

Paper contribution The contribution of the present paper is twofold. First, it derives the welfare implications of endogenous information in a micro-founded model when the central bank takes an action (i.e. James and Lawler (2011)) and when the action of the central bank provides a public signal (i.e. Baeriswyl and Cornand (2010)). Second, it compares the social welfare in the different operational frameworks (pure communication, action and communication, and signaling action) both under exogenous and endogenous information.

Choosing an optimal action under full opacity yields a higher welfare than under the pure communication and signaling action frameworks. However, in a context where full opacity cannot be reached, because central bank's action publicly reveals its beliefs about economic fundamentals, it may be optimal for the central bank to refrain from implementing any action. The endogenous nature of information enlarges the range of parameter values for which the absence of action is superior. Acknowledging the ambivalent role of the central bank, as an observer and a shaper of market outcomes, shows that the attempt to stabilise the economy does not always improve welfare, as it deteriorates the informational content of market prices.

Related literature Our paper contributes to a growing literature that accounts for the endogenous nature of information. In coordination games under heterogeneous information, endogenous information often refers to the case where market participants have an incentive to acquire exogenous, market-independent, information. This is the case in Burguet and Vives (2000), Hellwig and Veldkamp (2009), Myatt and Wallace (2012) or Paciello and Wiederholt (2014), where agents put effort at collecting private information. By contrast, our definition of endogenous information means that agents glean information from observing the market outcome, which results from the behaviour of market participants, as in the works by Grossman and Stiglitz (1980), Amador and Weill (2010), Hellwig and Venkateswaran (2011), Amador and Weill (2012), Atolia and Chahrour (2013), or Vives (2013). While these papers focus on the learning by market participants from information conveyed by prices, we focus on the learning by the policy maker. We are not the first

to draw attention to the issue of the decision maker learning from market prices. Bond et al. (2010) show that if the decision maker, such as the firm management, relies on market prices when deciding on corrective actions, prices may become less revealing about the true fundamental of the firm as they may already incorporate the corrective actions expected by market participants. They conclude that it may be desirable for the decision maker to rely less extensively on market-based information. Goldstein et al. (2011) analyse the theoretical implications of the informational feedback from market activities to policy decisions into a model of currency attacks. The central bank learns from the speculative trading in currency markets about the viability of its currency regime and uses the inferred information to guide its policy decisions. Again, they conclude that the central bank can improve the effectiveness of its policy by putting a lower weight on the information gleaned from the market. The same conclusion is drawn by Bond and Goldstein (2015), in the context of financial stability measures taken by governments such as bailouts or lending facilities.

Our paper departs from this recent literature as the central bank has no direct sources of private information about the economic fundamental and, thus, must observe the market activity to glean information. While the central bank may have market-independent sources of information in the context of speculative attacks (i.e. the level of its foreign exchange reserves) or financial stability (i.e. the balance sheet of financial institutions), typically the conduct of monetary policy does not benefit from such direct information about macroeconomic fundamentals.

An empirical literature has also highlighted that central bank's transparency tends to deteriorate the informative value of market outcome. In an analysis of U.S. data, Ehrmann and Fratzscher (2005) show that with increasing transparency "markets attach more importance to the statements and the balance-of-risk assessments at FOMC meetings and less importance to news about macroeconomic fundamentals." They conclude that "the reaction of financial markets to the release of macroeconomic fundamentals can be an important source of information for the central bank about the markets' diverse and possibly deviating views," and that "under its new disclosure strategy, the Federal Reserve has less such information available." Lustenberger and Rossi (2017) also find in an international analysis that more communication from central banks tends to increase errors and dispersion of professional forecasters.

The remaining of this paper is structured as follows. Section 2 presents the micro-founded model. Section 3 derives and compares welfare for three operational frameworks under exogenous information. Section 4 reconsiders these operational frameworks under endogenous information. Finally, section 5 concludes.

2 The economy

This section derives the theoretical Keynesian beauty contest from a micro-founded economy with flexible prices but heterogenous information. The model is based on Adam

(2007). The economy is populated by a representative household, a continuum of monopolistic competitive firms indexed on the unit interval $[0, 1]$, and a central bank. The economy is hit by stochastic labour supply shocks which shift the efficient level of output. The central bank seeks to stabilise the economy by taking a policy action that determines the nominal aggregate demand and/or by disclosing information about its economic assessment.

2.1 Representative household

The representative household chooses its aggregate composite good C and labour supply L in order to maximise its utility subject to its budget constraint,

$$U(C) - \nu V(L),$$

$$\text{s.t. } WL + \Pi = PC + T.$$

W denotes the competitive wage, Π the profits the household gets from firms, and T the nominal transfer from the central bank. The parameter ν is a stochastic labour supply shock that induces variations in the efficient level of output. The composite good C is defined by the Dixit-Stiglitz aggregator

$$C = \left[\int_0^1 (C_i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}},$$

where $\theta > 1$ is the parameter of price elasticity of demand and where C_i is the good produced by firm i . As θ is constant, there is no mark-up shock. P is the appropriate price index which solves $PY = \int_0^1 P_i C_i di$.

2.2 Firms

Each firm i produces a single differentiated good C_i with one unit of labour L_i according to the production function

$$L_i = C_i.$$

The profit maximisation problem of firm i is given by

$$\max_{P_i} \mathbb{E}[(1 + \tau)P_i C_i(P_i) - W C_i(P_i) | \Gamma_i],$$

where τ is an output subsidy that offsets the efficiency detrimental effect of the mark-up and Γ_i is the information set of firm i . Linearising the first order condition of firm i 's problem around its steady state delivers

$$p_i = \mathbb{E}_i[p + \xi(c - c^*)], \tag{1}$$

where \mathbb{E}_i is the expectation operator conditional on firm i 's information set Γ_i and where small letters indicate percentage deviation from the steady state. The pricing rule (1) states that firms set their price as a function of their expectations of the overall price level p and the real output gap $c - c^*$. The deviation of the efficient level of output c^* from its steady state is determined by the stochastic labour supply shifter ν . The parameter $\xi = -\frac{U''(\bar{Y})\bar{Y}}{U'(\bar{Y})} + \frac{V''(\bar{Y})\bar{Y}}{V'(\bar{Y})}$ determines the sensitivity of the optimal price to the output gap and is increasing in the risk aversion of the household.

Using the fact that the nominal aggregate demand g can be expressed as $g = c + p$, we rewrite the pricing rule (1) as

$$p_i = (1 - \xi)\mathbb{E}_i(p) + \xi\mathbb{E}_i(g - c^*). \quad (2)$$

Parameter ξ determines whether prices are strategic complements or substitutes. We assume that prices are strategic complements, i.e. $0 < \xi < 1$. This means that each firm tends to rise its own price when it expects other firms to do so.

The efficient level of output, i.e. the fundamental of the economy, is $c^* \in \mathbb{R}$. It reflects the aggregate level of firm's specific efficient output $c^* = \int_i x_i di$. Firm's specific efficient output is centered on the aggregated efficient level c^* and has a normally distributed error term:

$$x_i = c^* + \epsilon_i, \quad \text{with } \epsilon_i \sim \mathcal{N}(0, \sigma_\epsilon^2), \quad (3)$$

where ϵ_i are identically and independently distributed across firms. The firm's specific efficient output x_i is interpreted as a private signal about the aggregate efficient level of output c^* , which drives marginal costs and optimal pricing.

2.3 Welfare

The second-order approximation of the welfare of the representative household is given by

$$W_{micro} = -\frac{\theta}{\xi} \int_0^1 (p_i - p)^2 di - (c - c^*)^2 = -\frac{\theta}{\xi} \int_0^1 (p_i - p)^2 di - (g - p - c^*)^2. \quad (4)$$

The welfare decreases in both the dispersion of prices across firms $\int_0^1 (p_i - p)^2 di$ and the distortion of the effective output from the efficient level of output $(c - c^*)^2$. The weight assigned to price dispersion is determined by the price elasticity of demand θ in the Dixit-Stiglitz composite good and the output gap elasticity of optimal prices ξ .

In the debate about the social value of public information, the welfare effect of transparency is driven by the relative weight assigned to the dispersion of individual actions across agents and to the distortion of the aggregate action from the fundamental. Angeletos and Pavan (2007) highlight that the discrepancy between the equilibrium degree of coordination ($1 - \xi$ in our model) and the efficient degree of coordination (θ/ξ in our model) drives the welfare effect of public information.

For the sake of generality, welfare (4) is expressed as

$$W = -\lambda \int_0^1 (p_i - p)^2 di - (g - p - c^*)^2, \quad (5)$$

to encompass several cases discussed in the literature. The micro-founded welfare corresponds to (5) with $\lambda = \theta/\xi$. The model of Morris and Shin (2002) can thus also be captured in our framework. Their welfare, given by $-\int_i (p_i - c^*)^2 di$, corresponds to (5) with $\lambda = 1$ and $g = 0$, as the central bank takes no action.

2.4 The central bank

The central bank seeks to maximise the unconditional expected welfare (5). To achieve this task the central bank can disclose information about the fundamental to firms and/or take a policy action to determine the nominal aggregate demand, depending on the operational framework.

The central bank's information about the fundamental is written y and the variance of the central bank's expectation error is

$$\text{Var}[\mathbb{E}(c^*|y) - c^*] \equiv \sigma_\mu^2. \quad (6)$$

This definition allows us to solve generally for the equilibrium behaviour of firms before specifying whether central bank's information is exogenous (section 3) or endogenous (section 4).

On the one hand, the central bank provides firms with its viewpoint about the fundamental. The central bank communicates its information y with more or less ambiguity. We capture this ambiguity with the degree of opacity of its disclosure.³ The signal disclosed by the central bank and received by firm i is written as

$$y_i = y + \phi_i, \quad \text{with} \quad \phi_i \sim \mathcal{N}(0, \sigma_\phi^2). \quad (7)$$

The dispersion of individual noises σ_ϕ^2 determines the degree of opacity of the central bank. It implies by no means that the central bank discloses a specific signal to each firm. Rather, the idiosyncratic noise captures that each firm may interpret differently the same equivocal statement made by the central bank. The signal y_i can be considered as a "semi-public" signal. Under transparency, all firms get the same unequivocal signal ($\sigma_\phi^2 = 0$). Then, the central bank's disclosure y is a public signal that is common knowledge among firms. Under opacity, the individual signal received by each firm has an infinite idiosyncratic noise ($\sigma_\phi^2 \rightarrow \infty$). The central bank's disclosure thus does not contain any

³This specification is more general than the public signal considered in Morris and Shin (2002) and James and Lawler (2011), where the central bank chooses between disclosing a fully transparent signal or withholding information completely. Our formulation of the public signal – with both common and idiosyncratic noise – is more realistic. For more details on the characteristics of semi-public information in these games, see Cornand and Heinemann (2008), Baeriswyl and Cornand (2014), Myatt and Wallace (2012) and Myatt and Wallace (2014).

valuable information.

On the other hand, the central bank can take an action (when provided by the operational framework) to stabilise the economy. Through its monetary policy action, the central bank determines the nominal aggregate demand

$$g = \rho \cdot y,$$

where ρ is the monetary policy coefficient.

2.5 Equilibrium

This section derives the perfect Bayesian equilibrium behaviour of firms. To calculate the optimal rule (2), we calculate the first-order and higher-order expectations of firm i about the fundamental c^* conditional on its information. Given firms' information (3), (6) and (7), the expectation of degree one about the fundamental $\mathbb{E}_i(c^*)$ yields

$$\mathbb{E}_i(c^*) = \frac{\sigma_\mu^2 + \sigma_\phi^2}{\sigma_\epsilon^2 + \sigma_\mu^2 + \sigma_\phi^2} x_i + \frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + \sigma_\mu^2 + \sigma_\phi^2} y_i. \quad (8)$$

The best estimate of the fundamental by firm i is an average of both its signals, which weights depend on their relative precision. To compute the higher-order expectations of firm i , one needs also to know the expectation of degree one of the central bank's average disclosure $\mathbb{E}_i(y)$. This delivers

$$\mathbb{E}_i(y) = \frac{\sigma_\phi^2}{\sigma_\epsilon^2 + \sigma_\mu^2 + \sigma_\phi^2} x_i + \frac{\sigma_\epsilon^2 + \sigma_\mu^2}{\sigma_\epsilon^2 + \sigma_\mu^2 + \sigma_\phi^2} y_i. \quad (9)$$

Because the equilibrium decision is a linear combination of expectations ($\mathbb{E}_i(c^*)$ and $\mathbb{E}_i(p)$) and that $\mathbb{E}_i(c^*)$ is itself a linear combination of signals, the equilibrium decision of any firm i is a linear combination of x_i and y_i

$$p_i = \gamma_1 x_i + \gamma_2 y_i, \quad (10)$$

and the average decision is

$$p = \gamma_1 c^* + \gamma_2 y.$$

Plugging this in (2) and using the expressions of expectations (8) and (9), we get an expression of p_i as a function of x_i and y_i . This expression is also equal to (10), which allows to identify coefficients γ_1 and γ_2 :

$$\gamma_1 = -\frac{\xi \sigma_\mu^2 + (1 - \rho) \sigma_\phi^2}{\sigma_\epsilon^2 + \xi \sigma_\mu^2 + \sigma_\phi^2}, \quad \gamma_2 = -\frac{(1 - \rho) \sigma_\epsilon^2 - \rho \xi \sigma_\mu^2}{\sigma_\epsilon^2 + \xi \sigma_\mu^2 + \sigma_\phi^2}, \quad \text{with } \gamma_1 + \gamma_2 = \rho - 1. \quad (11)$$

Given the equilibrium behaviour of firms (11) and central bank's information, the

unconditional expected social welfare (5) can be written as

$$\mathbb{E}(W) = -\lambda(\gamma_1^2\sigma_\epsilon^2 + \gamma_2^2\sigma_\phi^2) - (\rho - \gamma_2)^2\sigma_\mu^2. \quad (12)$$

The central bank chooses its disclosure strategy σ_ϕ^2 and action ρ (depending on the operational framework) to maximise the unconditional expected welfare.

2.6 Operational frameworks

Optimal central bank's policy is derived within three operational frameworks. An operational framework refers to the communication and action instruments at the disposal of the central bank.

- Under pure communication (PC), the central bank can solely disclose information. This framework corresponds to that of Morris and Shin (2002), which features how the central bank should optimally communicate when it takes no action. Our framework departs nevertheless from MS in that it allows the central bank to choose an intermediate degree of opacity, while the original formulation of MS limits the choice between disclosing fully transparent information or withholding information completely.
- Under action and communication (AC), the central bank can take an action and disclose information. This framework corresponds to that of James and Lawler (2011), which features how the central bank should optimally combine its action and disclosure.
- Under signaling action (SA), the action taken by the central bank is common knowledge. This framework corresponds to that of Baeriswyl and Cornand (2010), which features how the central bank should optimally take its action when the latter is perfectly observable by firms.⁴

These three frameworks are nested. AC yields the unrestricted optimum as the central bank unrestrictedly chooses its action and disclosure. PC is nested in AC by excluding the possibility of taking an action (i.e. by setting $\rho = 0$). SA is also nested in AC and PC by imposing full transparency of the central bank (i.e. by setting $\sigma_\phi^2 = 0$).⁵

These three operational frameworks are solved for two processes of information gathering by the central bank. Under exogenous information, the central bank directly observes the fundamental with some noise. The precision of central bank's information is exogenous in the sense that it is independent of the behaviour of market participants (section 3). Under endogenous information, the central bank does not directly observe the fundamental but instead watches the economic outcome to evaluate the state of the fundamental. In

⁴Note that contrary to the present paper, in Baeriswyl and Cornand (2010) the signaling action does not unambiguously reveal central bank's information because the economy is affected by two shocks.

⁵As the three operational frameworks are nested, they are (weakly) welfare ranked, with AC dominating PC and PC dominating SA.

this case, the precision of central bank's information is endogenous because it is determined by how the central bank influences the economy (section 4).

3 Exogenous information

This section analyses the welfare effects of disclosure and action when central bank's information is exogenous. The central bank directly observes the fundamental with some noise. According to the error term of central bank's information (6), the central bank receives a signal y on the fundamental that is centered on its true value c^* and contains an error term μ :

$$y = c^* + \mu, \quad \text{with } \mu \sim \mathcal{N}(0, \sigma_\mu^2).$$

The precision of central bank's information σ_μ^2 is exogenous and independent of its behaviour. The present section serves as a benchmark for the analysis under endogenous information presented in section 4.

3.1 Optimal central bank's behaviour

We derive the optimal central bank's disclosure and/or action for the three operational frameworks under scrutiny before comparing these operational frameworks with each other.

3.1.1 Pure communication

The first operational framework corresponds to Morris and Shin (2002), where the central bank discloses information but takes no action. This case is captured in our general set-up by imposing $\rho = 0$. Plugging the equilibrium response of agents (11) into (12) yields the unconditional expected welfare

$$\mathbb{E}(W|_{\rho=0}) = - \frac{\left(\lambda \left(\xi \sigma_\mu^2 + \sigma_\phi^2 \right)^2 + \sigma_\epsilon^2 (\sigma_\mu^2 + \lambda \sigma_\phi^2) \right) \sigma_\epsilon^2}{\left(\sigma_\epsilon^2 + \xi \sigma_\mu^2 + \sigma_\phi^2 \right)^2}.$$

Differentiating with respect to σ_ϕ^2 and setting the resulting expression to zero gives the optimal degree of opacity

$$\sigma_\phi^{2*} = \max \left[0, \left(\frac{2}{\lambda} - 3\xi \right) \sigma_\mu^2 - \sigma_\epsilon^2 \right]. \quad (13)$$

The intuition behind the optimal degree of opacity is driven by the dual effect of public information on welfare. On the one hand, less opaque public information improves welfare by reducing price dispersion across firms. On the other hand, noisy public information is detrimental to welfare by increasing the distortion of output from its efficient level.

The optimal degree of opacity increases with the degree of strategic complementarities $1 - \xi$. Stronger strategic complementarities induce firms to assign a higher relative weight

to their public information. While this reduces the price dispersion across firms, this exacerbates the distortion from efficient output, in reaction to which the central bank finds it optimal to increase the degree of opacity of its disclosure.

The optimal degree of opacity decreases with the weight assigned to price dispersion λ in welfare. When the relevance of price dispersion increases compared to that of output distortion, a more transparent central bank's disclosure helps firms to coordinate their price setting.

The optimal degree of opacity decreases with the inaccuracy of private information σ_ϵ^2 . When private information becomes less accurate (σ_ϵ^2 increases), it is optimal for the central bank to reduce its opacity to enhance the coordination of firms through a relatively more transparent disclosure.

Finally, the effect of the inaccuracy of central bank's information σ_μ^2 is ambiguous. The optimal degree of opacity increases with the inaccuracy of central bank's information when $2/3 > \lambda\xi$. As inaccurate central bank's information yields a distortion of output, an increase in inaccuracy calls for more opacity when the relative weight of distortion in welfare is large (i.e. λ small) and when firms strongly react to the central bank's disclosure because of a large degree of strategic complementarities (i.e. ξ small).

In the particular case where the efficient degree of coordination accepts its micro-founded value, i.e. $\lambda = \theta/\xi$, an increase in the inaccuracy of central bank's information yields a lower optimal degree of opacity. In this case, however, full transparency is always optimal:

$$\sigma_\phi^{2*} |_{\rho=0, \lambda=\theta/\xi} = \max[0, \frac{2\xi-3\theta\xi}{\theta} \sigma_\mu^2 - \sigma_\epsilon^2] = 0,$$

as $\theta > 1$ and $0 < \xi < 1$. This conforms to the result of Hellwig (2005) and Angeletos and Pavan (2007) according to which full transparency is optimal when the efficient degree of coordination exceeds the equilibrium degree of coordination, i.e. $\theta/\xi > 1 - \xi$.

Under partial transparency, i.e. $\sigma_\phi^{2*} = (\frac{2}{\lambda} - 3\xi) \sigma_\mu^2 - \sigma_\epsilon^2$, the expected welfare yields

$$\mathbb{E}(W |_{\rho=0, \sigma_\phi^{2*}=(2/\lambda-3\xi)\sigma_\mu^2-\sigma_\epsilon^2}) = -\lambda\sigma_\epsilon^2 + \frac{\lambda^2\sigma_\epsilon^4}{4(1-\lambda\xi)\sigma_\mu^2}.$$

Under full transparency, i.e. $\sigma_\phi^{2*} = 0$, the expected welfare is given by

$$\mathbb{E}(W |_{\rho=0, \sigma_\phi^{2*}=0}) = -\frac{(\sigma_\epsilon^2 + \lambda\xi^2\sigma_\mu^2)\sigma_\epsilon^2\sigma_\mu^2}{(\sigma_\epsilon^2 + \xi\sigma_\mu^2)^2}$$

and in the micro-founded case with $\lambda = \theta/\xi$ the corresponding expected welfare is

$$\mathbb{E}(W |_{\rho=0, \lambda=\theta/\xi, \sigma_\phi^{2*}=0}) = -\frac{(\sigma_\epsilon^2 + \theta\xi\sigma_\mu^2)\sigma_\epsilon^2\sigma_\mu^2}{(\sigma_\epsilon^2 + \xi\sigma_\mu^2)^2}.$$

3.1.2 Action and communication

In the second operational framework, the central bank can both take an action and disclose information, as in James and Lawler (2011). First the optimal policy action of the central bank is obtained by differentiating (12) with respect to ρ , holding σ_ϵ^2 , σ_μ^2 , σ_ϕ^2 , ξ , and λ fixed. This yields the optimal policy action

$$\rho^* = \frac{\left(\lambda\sigma_\epsilon^2 + (2\lambda\xi - 1)\sigma_\mu^2 + \lambda\sigma_\phi^2\right)\sigma_\epsilon^2}{\left(\lambda\sigma_\epsilon^2 + \sigma_\mu^2\right)\sigma_\phi^2 + \lambda\left(\sigma_\epsilon^2 + \xi\sigma_\mu^2\right)^2}. \quad (14)$$

We then derive the optimal disclosure when the central bank implements the optimal policy action ρ^* . Plugging ρ^* in (12) yields the welfare function

$$\mathbb{E}(W|\rho^*) = -\frac{\left(\sigma_\epsilon^2 + \lambda\xi^2\sigma_\mu^2 + \sigma_\phi^2\right)\lambda\sigma_\epsilon^2\sigma_\mu^2}{\left(\lambda\sigma_\epsilon^2 + \sigma_\mu^2\right)\sigma_\phi^2 + \lambda\left(\sigma_\epsilon^2 + \xi\sigma_\mu^2\right)^2}.$$

Differentiating this expression with respect to σ_ϕ^2 yields

$$\frac{\partial\mathbb{E}(W|\rho^*)}{\partial\sigma_\phi^2} = \frac{(\lambda\xi - 1)^2\lambda\sigma_\epsilon^4\sigma_\mu^4}{\left(\left(\lambda\sigma_\epsilon^2 + \sigma_\mu^2\right)\sigma_\phi^2 + \lambda\left(\sigma_\epsilon^2 + \xi\sigma_\mu^2\right)^2\right)^2}, \quad (15)$$

which is always positive. For any parameter value, it is welfare improving for the central bank to increase the noise in the semi-public signal, and thus full opacity is optimal.

Under full opacity, i.e. $\sigma_\phi^2 \rightarrow \infty$, the optimal central bank's action is given by

$$\rho^*|_{\sigma_\phi^2 \rightarrow \infty} = \frac{\lambda\sigma_\epsilon^2}{\lambda\sigma_\epsilon^2 + \sigma_\mu^2}, \quad (16)$$

and the expected welfare writes

$$\mathbb{E}(W|\rho^*, \sigma_\phi^2 \rightarrow \infty) = -\frac{\lambda\sigma_\epsilon^2\sigma_\mu^2}{\lambda\sigma_\epsilon^2 + \sigma_\mu^2}.$$

This result corroborates that of James and Lawler (2011) when $\lambda = 1$: public disclosure of central bank's information always deteriorates welfare whenever the central bank takes an action. Considering the micro-founded case where $\lambda = \theta/\xi$ does not alter this result. Even when the central bank has some information of very high quality, it is optimal not to communicate this information.

Taking an action is more efficient for maximising welfare than disclosing information. While firms overreact to public disclosures because of strategic complementarities in price setting, they do not overreact to unobserved actions. Firms know, in principle, that the central bank takes an action but ignore which action is exactly taken. Deprived of central bank's disclosure, each firm builds its own expectation about central bank's action based on its private information only. Accounting for privately expected central bank's

action, firms react less to their private information which reduces price dispersion without inducing an overreaction to any noisy central bank's disclosure.

Note, however, that taking an action without disclosing any information to market participants seems unrealistic. The next operational framework states that the action taken by the central bank signals its economic assessment even in the absence of an explicit disclosure.

3.1.3 Signaling action

While the central bank could take an action without disclosing any information in the previous section, we now consider a third more realistic operational framework where taking an action also signals what the central bank believes about the state of the economy. Indeed, although the central bank may not explicitly communicate about its beliefs, its action is always observable and, thereby, reveals its beliefs about the economic fundamental, as highlighted in Baeriswyl and Cornand (2010).

Consider the case where central bank's action is perfectly observable by agents, i.e. $\sigma_\phi^2 = 0$. Differentiating (12) with respect to ρ shows that the optimal action is indeterminate, as any common knowledge policy coefficient yields the same optimal welfare. For the sake of simplicity, we stipulate that the central bank fully accommodates the expected fundamental with $\rho^* = 1$.⁶ The expected welfare writes

$$\mathbb{E}(W|_{\rho^*, \sigma_\phi^2=0}) = -\frac{(\sigma_\epsilon^2 + \lambda\xi^2\sigma_\mu^2)\sigma_\epsilon^2\sigma_\mu^2}{(\sigma_\epsilon^2 + \xi\sigma_\mu^2)^2}.$$

In the micro-founded case where $\lambda = \theta/\xi$, the expected welfare is

$$\mathbb{E}(W|_{\rho^*, \sigma_\phi^2=0, \lambda=\theta/\xi}) = -\frac{(\sigma_\epsilon^2 + \theta\xi\sigma_\mu^2)\sigma_\epsilon^2\sigma_\mu^2}{(\sigma_\epsilon^2 + \xi\sigma_\mu^2)^2}.$$

After having derived the optimal behaviour of the central bank in three different operational frameworks, the next section compares these frameworks at their respective optimum.

3.2 Optimal operational framework

Table 1 summarises the optimal central bank's behaviour under pure communication (PC), action and communication (AC), and signaling action (SA). The first line also shows the welfare when the central bank neither talks nor takes any action (no CB). In this section we compare these operational frameworks to each other.

Figure 1 illustrates the weight assigned by firms to their private information γ_1 , the weight assigned by firms to the central bank's disclosure γ_2 , the central bank's action

⁶One way to solve the indeterminacy of optimal action would be to introduce sticky information in the model and to take the optimal action at the limit when information stickiness converges towards zero, as in Baeriswyl and Cornand (2010). This would however not affect welfare in this model.

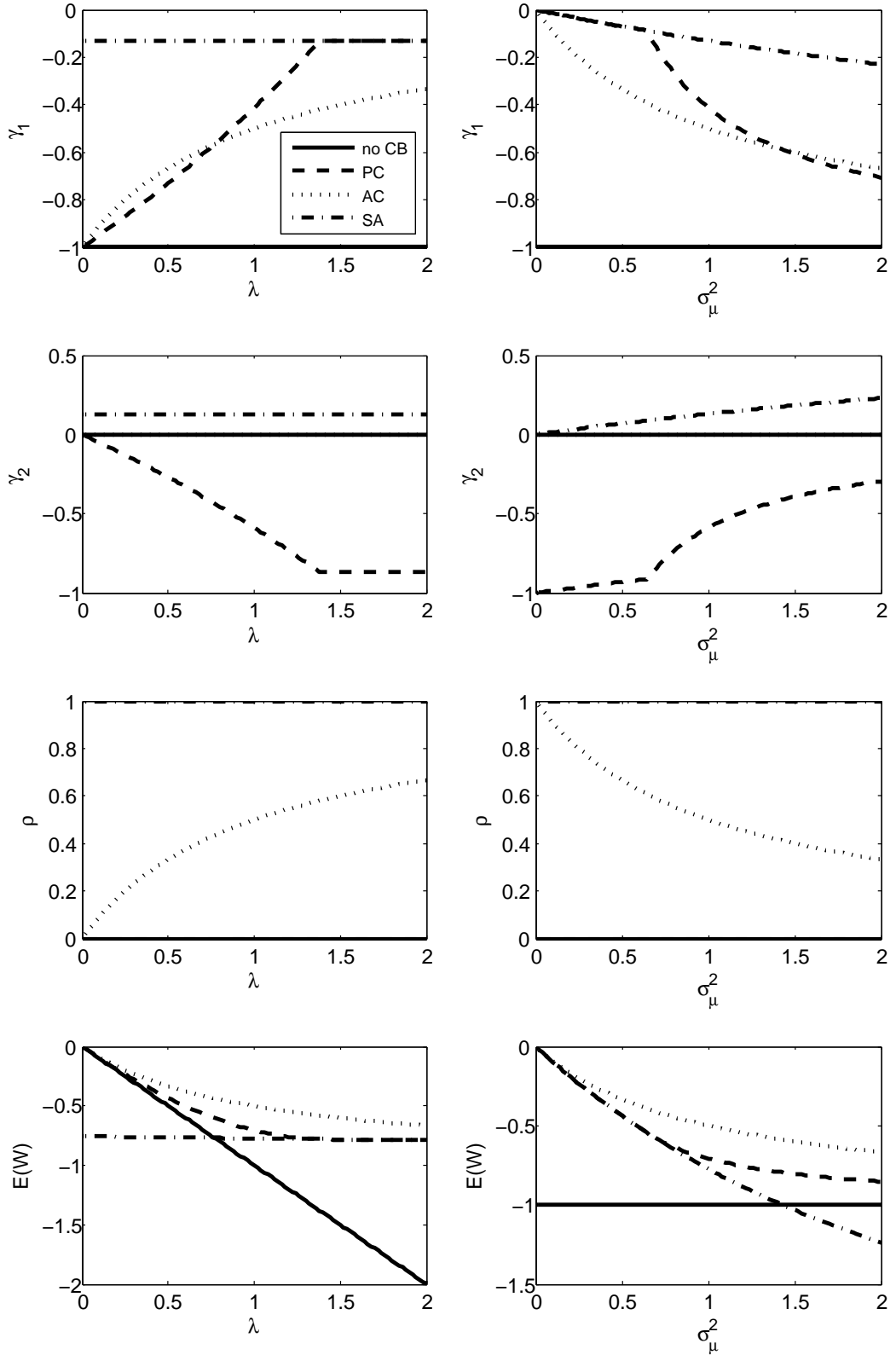


Figure 1: Optimal firms' and central bank's behaviour and unconditional expected welfare under exogenous information as a function of λ and σ_μ^2 for $\sigma_\epsilon^2 = 1$, $\xi = 0.15$, $\sigma_\mu^2 = 1$ (left plots), and $\lambda = 1$ (right plots)

	σ_ϕ^2	ρ	$\mathbb{E}(W)$
No CB	∞	0	$-\lambda\sigma_\epsilon^2$
PC if $(2/\lambda - 3\xi)\sigma_\mu^2 \leq \sigma_\epsilon^2$	0	0	$-\frac{(\sigma_\epsilon^2 + \lambda\xi^2\sigma_\mu^2)\sigma_\epsilon^2\sigma_\mu^2}{(\sigma_\epsilon^2 + \xi\sigma_\mu^2)^2}$
otherwise	$(2/\lambda - 3\xi)\sigma_\mu^2 - \sigma_\epsilon^2$	0	$-\lambda\sigma_\epsilon^2 + \frac{\lambda^2\sigma_\epsilon^4}{4(1-\lambda\xi)\sigma_\mu^2}$
AC	∞	$\frac{\lambda\sigma_\epsilon^2}{\lambda\sigma_\epsilon^2 + \sigma_\mu^2}$	$-\frac{\lambda\sigma_\epsilon^2\sigma_\mu^2}{\lambda\sigma_\epsilon^2 + \sigma_\mu^2}$
SA	0	1	$-\frac{(\sigma_\epsilon^2 + \lambda\xi^2\sigma_\mu^2)\sigma_\epsilon^2\sigma_\mu^2}{(\sigma_\epsilon^2 + \xi\sigma_\mu^2)^2}$

Table 1: Expected welfare in various operational frameworks

ρ , and the unconditional expected welfare $\mathbb{E}(W)$ in the different operational frameworks. Plots on the left show simulations as a function of λ and plots on the right as a function of σ_μ^2 .

First, the action and communication framework yields a higher welfare than the pure communication and signaling action frameworks. Choosing an optimal action under full opacity is the welfare superior strategy. When price setting entails strategic complementarities, firms overreact to the central bank's disclosure, which yields a distortion of the average price because of the error term σ_μ^2 . However, while the central bank takes an action under full opacity, firms anticipate the action taken by the central bank into their price setting decision without overreacting to its error term. This reduces the price dispersion across firms without creating a distortion due to the central bank's error term.

Second, when partial transparency is optimal under the pure communication framework, i.e. when $(2/\lambda - 3r)\sigma_\mu^2 > \sigma_\epsilon^2$ or $\lambda < 1.379$ on left plots or $\sigma_\mu^2 > 0.645$ on right plots, pure communication is superior to taking a signaling action. When full transparency is optimal under the pure communication framework, i.e. $(2/\lambda - 3r)\sigma_\mu^2 \leq \sigma_\epsilon^2$ or $\lambda > 1.379$ on left plots, or $\sigma_\mu^2 < 0.645$ on right plots, pure communication and signaling action are equivalent. The pure communication framework allows a subtle control of the overreaction of firms to the central bank's disclosure through varying the degree of opacity. By contrast, the signaling action framework specifies that the action taken by the central bank is perfectly observable, which makes controlling overreaction impossible. So, whenever increasing the degree of opacity is optimal under pure communication, this framework consequently yields a higher welfare than under the signaling action framework.

Finally, doing nothing (no CB) yields a higher welfare than taking a signaling action when $(1 - 2\lambda\xi)\sigma_\mu^2 - \lambda\sigma_\epsilon^2 > 0$ or $\lambda < 0.769$ on left plots or $\sigma_\mu^2 > 1.429$ on right plots. When the relative weight of price dispersion in welfare λ is low or when the inaccuracy of central bank's information σ_μ^2 is high, unconditional expected welfare is higher when the central bank refrains from influencing the economy than when it takes an action which is perfectly observable. This result coincides with the original formulation of Morris and Shin (2002), whereby the central bank chooses between disclosing fully transparent information and withholding information completely.

Svensson (2006) observed that Morris and Shin (2002) anti-transparency result only

holds in the unrealistic case where central bank's information is less accurate than that of private agents. Svensson's critic also applies in our exogenous model. When welfare equally weights price dispersion and distortion, i.e. when $\lambda = 1$, taking a signaling action is inferior to the absence of central bank only in the unrealistic case where the accuracy of central bank's information ($\sigma_\mu^2 > 1.429$) is significantly worse than that of private firms' information ($\sigma_\epsilon^2 = 1$). As we shall see in the next section, endogenous information qualifies Svensson's critic as the absence of central bank turns to be superior to taking a signaling action for more realistic parameter values.

4 Endogenous information

The endogenous information set-up departs from the unrealistic assumption that the central bank directly observes economic fundamentals. Fundamentals typically result from human actions. While fundamentals such as the crop production or rainfall are independent of human behaviour, most economic fundamentals such as aggregated demand, supply, investment, inflation, or preferences reflect the behaviour of economic agents. Observing fundamentals, thus, means observing economic agents. In reality, the central bank has no direct source of information about economic fundamentals but observes the aggregate market activity to assess the state of the economy.

To capture the endogenous nature of information about fundamentals, we postulate that the central bank receives a signal Ω on the average decision p with some noise η

$$\Omega = p + \eta = \gamma_1 c^* + \gamma_2 y + \eta, \quad \eta \sim \mathcal{N}(0, \sigma_\eta^2).$$

Using (11) and the fact that $\gamma_1 + \gamma_2 = \rho - 1$, the central bank's best estimate of the fundamental conditional on its observation is $\mathbb{E}(c^* | \Omega) = \Omega / (\rho - 1) = y$. The information of the central bank can thus be expressed as

$$\begin{aligned} \Omega &= \gamma_1 c^* + \gamma_2 \frac{\Omega}{\rho - 1} + \eta \\ &= (\rho - 1)c^* + \frac{\rho - 1}{\gamma_1} \eta. \end{aligned}$$

It is important to stress that the central bank cannot infer the true fundamental c^* from its observation of the aggregate decision Ω , even if the central bank knows which signal it discloses to firms because its observation contains an unknown error η . According to the definition of (6), the variance of central bank's expectation error under endogenous information becomes

$$\text{Var} [\mathbb{E}(c^* | \Omega) - c^*] = \frac{\sigma_\eta^2}{\gamma_1^2} \equiv \sigma_\mu^2. \quad (17)$$

The precision of central bank's information is a function of the equilibrium response of firms γ_1 , which depends on the action and communication strategy of the central bank.

The analysis focuses on the simultaneous equilibrium (fixed point) between the central bank and the market outcome. To implement its policy, the central bank observes the market outcome Ω , which is, at the same time, influenced by its action and disclosure. Focusing on simultaneous equilibrium is a shortcut for analysing the steady-state or continuous interaction between the central bank and firms. In reality, monetary policy continuously influences the economy, which feeds back into policy decisions. Thus, the central bank cannot first observe an economy uninfluenced by its policy and then take the appropriate decision to shape the economy. Rather, the feedback process between the economy and policy is continuous.

In the following subsections, we analyse the consequences of endogenous central bank's information on its accuracy and on welfare for the three operational frameworks under scrutiny. We derive welfare for each operational framework before comparing these operational frameworks at their respective optimum.

4.1 Optimal central bank's behaviour

Solving analytically the optimisation problem of the central bank is not straightforward under endogenous information because the relationship between the variance of central bank's expectation error and firms' response is non-linear. Plugging (17) into (11) yields

$$\gamma_1 = -\frac{\xi\sigma_\eta^2/\gamma_1^2 + (1-\rho)\sigma_\phi^2}{\sigma_\epsilon^2 + \xi\sigma_\eta^2/\gamma_1^2 + \sigma_\phi^2}, \quad (18)$$

which exhibits three equilibria. The cubic equation has only one real root (and two complex conjugate roots) when its discriminant is negative, which is satisfied when $\rho \in [0, 1]$ (and $0 < \xi < 1$). While assuming a monetary policy coefficient $\rho \in [0, 1]$ gets rid of the indeterminacy of multiple equilibria, it means that the central bank, realistically, seeks to accommodate shocks to the fundamental rather than to amplify them (i.e. $\rho < 0$) or over-accommodate them (i.e. $\rho > 1$). As algebraic solutions remain cumbersome, we apply numerical procedures in the following.⁷

4.1.1 Pure communication

Let us consider the first operational framework, in which the central bank discloses information but implements no action ($\rho = 0$). Under endogenous information, central bank's disclosure affects the accuracy of the average price set by firms as an indicator of the economic fundamental. The informative value of the average price p is evaluated as the variance of the error of fundamental expectations conditional on the average price:

$$\text{Var} [\mathbb{E}(c^*|p) - c^*] = \text{Var} \left[\mathbb{E} \left(c^* | c^* + \frac{\gamma_2}{\gamma_1} \eta \right) - c^* \right] = \frac{\gamma_2^2}{\gamma_1^2} \sigma_\eta^2.$$

⁷Matlab codes for solving the model under endogenous information are available from the authors upon request.

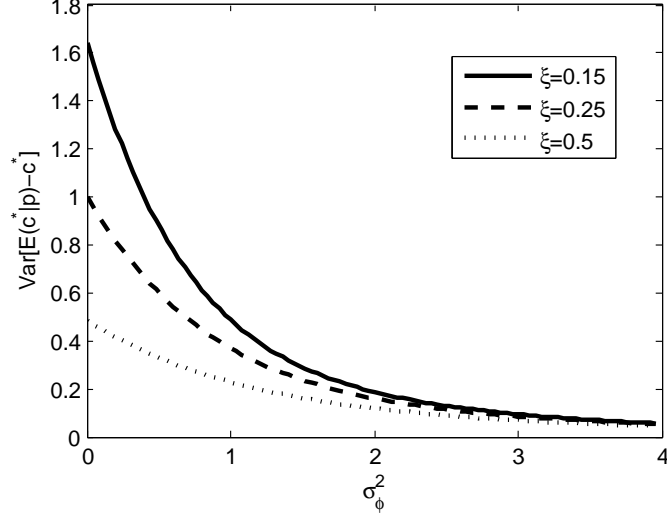


Figure 2: Informative value of average price for $\sigma_\epsilon^2 = 1$, $\sigma_\eta^2 = 1$, and $\rho = 0$

The effect of central bank's communication on the informative value of the average price is illustrated on Figure 2 in the case of pure communication. The information about the fundamental contained in the average price increases with central bank's opacity σ_ϕ^2 . Increasing opacity reduces the influence of the central bank on the decision of firms, which improves the informative value of the average price about the fundamental. When the central bank is completely opaque, i.e. when $\sigma_\phi^2 \rightarrow \infty$, firms do not react to the central bank's disclosure at all and the average price becomes a perfect indicator for the fundamental c^* . The degree of strategic complementarities ξ drives the overreaction of firms to the central bank's disclosure and, thereby, affects the information contained in the average price. A higher degree of strategic complementarities reduces the informative value of the average price as firms react more to the central bank's disclosure.

Central bank's opacity exerts a dual effect on the accuracy of firms' information. On the one hand, an increase in opacity rises the idiosyncratic noise of the central bank's disclosure σ_ϕ^2 , which deteriorates the accuracy of firms' information. On the other hand, an increase in opacity improves the informative value of the average price and the accuracy of central bank's information and disclosure. Overall, opacity exerts an ambiguous effect on the accuracy of firms' information. This is evaluated by the variance of the error of fundamental expectations conditional on both the private signal x_i and the central bank's disclosure y_i :

$$\begin{aligned}
\text{Var} [\mathbb{E}(c^*|x_i, y_i) - c^*] &= \text{Var} \left[\mathbb{E}(c^*|c^* + \epsilon_i, c^* + \frac{\eta}{\gamma_1} + \phi_i) - c^* \right] \\
&= \text{Var} \left[\frac{(\sigma_\eta^2/\gamma_1^2 + \sigma_\phi^2)(\theta + \epsilon_i) + \sigma_\epsilon^2(\theta + \eta/\gamma_1 + \phi_i)}{\sigma_\epsilon^2 + \sigma_\eta^2/\gamma_1^2 + \sigma_\phi^2} - \theta \right] \\
&= \frac{(\sigma_\eta^2/\gamma_1^2 + \sigma_\phi^2)\sigma_\epsilon^2}{\sigma_\epsilon^2 + \sigma_\eta^2/\gamma_1^2 + \sigma_\phi^2}.
\end{aligned}$$

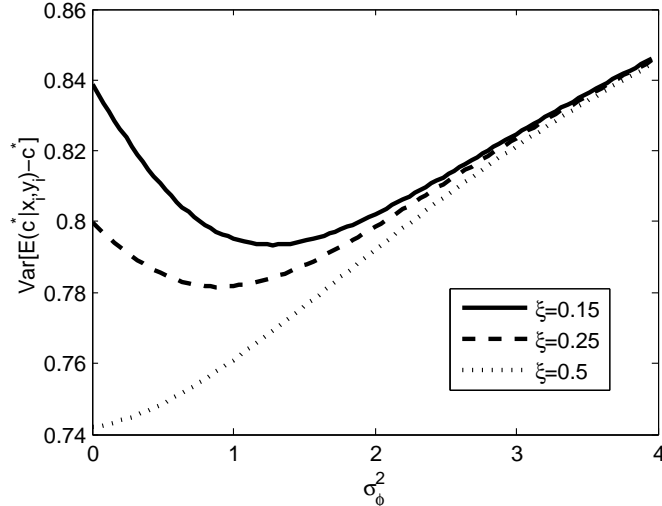


Figure 3: Informative value of firms' information for $\sigma_\epsilon^2 = 1$, $\sigma_\eta^2 = 1$, and $\rho = 0$

The effect of central bank's communication on the accuracy of firms' information is illustrated on Figure 3. When the degree of strategic complementarities is low ($\xi = 0.5$), increasing opacity deteriorates the accuracy of firms' information. By contrast, for a higher degree of strategic complementarities ($\xi = 0.25$ and $\xi = 0.15$), increasing opacity does not unambiguously deteriorate the accuracy of firms' information. Below a certain threshold, increasing opacity improves the accuracy of firms' information: the rise in the informative value of the average price overcomes the rise in the idiosyncratic noise.

We now turn to the effect of endogenous central bank's information on welfare. Figure 4 plots the expected welfare as a function of opacity for $\sigma_\epsilon^2 = 1$, $\sigma_\eta^2 = 1$, $\lambda = 2$, and $\rho = 0$. It shows that, depending on the degree of strategic complementarities, full transparency may (or not) be preferable to full opacity and that there is an interior optimal degree of opacity. The optimal degree of opacity increases with the degree of strategic complementarities and its algebraic solution is given by

$$\sigma_\phi^{2*} = \max \left[0, \left(\frac{2}{\lambda} - 3\xi \right) \sigma_\eta^2 / \gamma_1^2 \right].$$

Endogenous information calls for a higher degree of opacity than exogenous information. Figure 5 compares the optimal degree of opacity under endogenous and exogenous informational set-ups, as a function of the degree of strategic complementarities ξ . The dotted line plots the optimal degree of opacity when the variance of central bank's expectation error is exogenous. This corresponds to (13) with $\sigma_\mu^2 = 1$. Accounting for the endogeneity of central bank's information exerts a twofold effect on the optimal degree of opacity. First, endogenous information raises the optimal degree of opacity because it deteriorates the accuracy of central bank's information. Even if the central bank ignores the effect of its disclosure on the accuracy of its observation, it should increase opacity as the accuracy deteriorates. This effect is plotted by the dashed line: central bank's

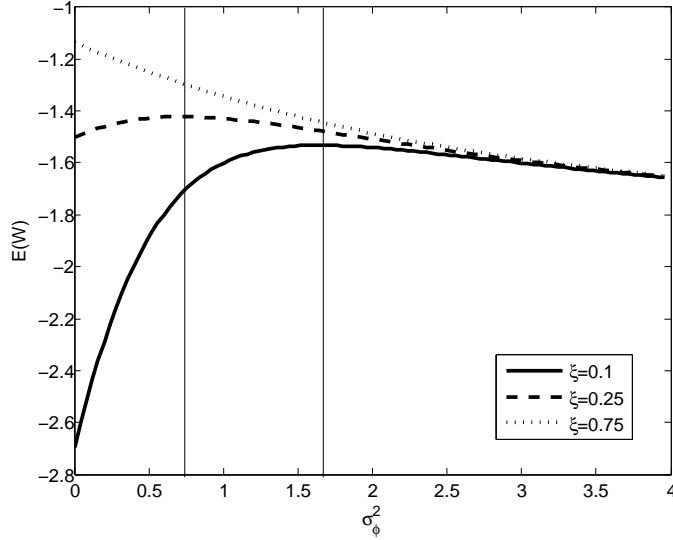


Figure 4: Expected welfare with pure communication as a function σ_ϕ^2 for $\sigma_\epsilon^2 = 1$, $\sigma_\eta^2 = 1$, $\lambda = 2$ and $\rho = 0$

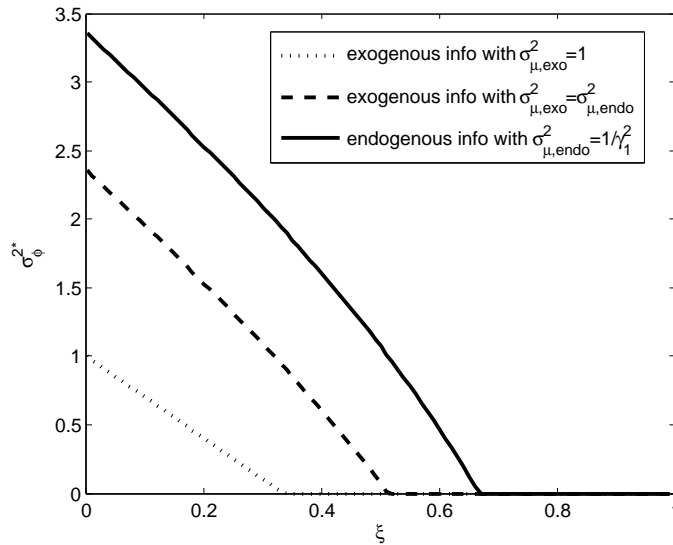


Figure 5: Optimal degree of opacity under pure communication as a function ξ for $\sigma_\epsilon^2 = 1$, $\sigma_\eta^2 = 1$, $\lambda = 1$ and $\rho = 0$

information is more accurate in the exogenous set-up $\sigma_{\mu,exo}^2 = 1$ than in the endogenous one $\sigma_{\mu,endo}^2 = 1/\gamma_1^2 > 1$. Second, endogenous information raises the optimal degree of opacity when the central bank accounts for the effect of its disclosure on the accuracy of its observation. The solid line plots the optimal degree of opacity in the endogenous set-up. Endogenous information creates an externality, which calls for more opacity than in the case of exogenous information. The difference between the optimal degree of opacity under endogenous information and that under exogenous information for a given level of information accuracy ($\sigma_{\mu,exo}^2 = \sigma_{\mu,endo}^2 = \sigma_\eta^2/\gamma_1^2$) is σ_ϵ^2 .

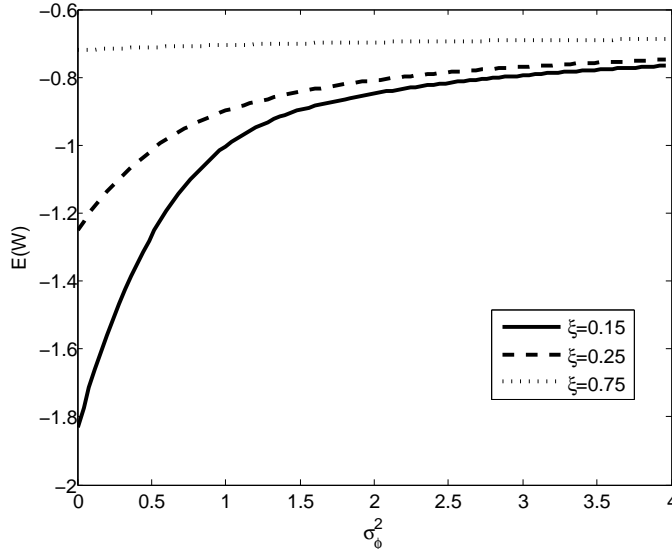


Figure 6: Unconditional expected welfare with optimal action ρ^* as a function of σ_ϕ^2 for $\sigma_\epsilon^2 = 1$, $\sigma_\eta^2 = 1$, and $\lambda = 1$

4.1.2 Action and communication

We now focus on the second operational framework, in which the central bank implements a policy action in addition to disclosing information. Accounting for the endogeneity of central bank's information does not alter the conclusion reached under exogenous information with respect to the optimal degree of opacity. Figure 6 plots the unconditional expected welfare when the central bank implements an optimal action as a function of the degree of opacity σ_ϕ^2 . Welfare is strictly increasing with the degree of opacity such that full opacity is optimal when the central bank takes an optimal action. This result corroborates that of James and Lawler (2011) under exogenous information.

Under full opacity, the optimal action is independent of the degree of strategic complementarities because there is no public information. Figure 7 traces the optimal action under full opacity for exogenous and endogenous central bank's information. As central bank's information is less accurate in the endogenous set-up, the central bank accommodates less strongly shocks to the fundamental.

4.1.3 Signaling action

We now turn to the third operational framework, in which the action taken by the central bank is common knowledge among firms and signals its information on the fundamental state of the economy. As in the exogenous set-up, the optimal action is also indeterminate under endogenous central bank's information. For the sake of simplicity, we stipulate that the central bank fully accommodates the expected fundamental with $\rho^* = 1$.

The next section assesses the three operational frameworks under endogenous information with respect to welfare.

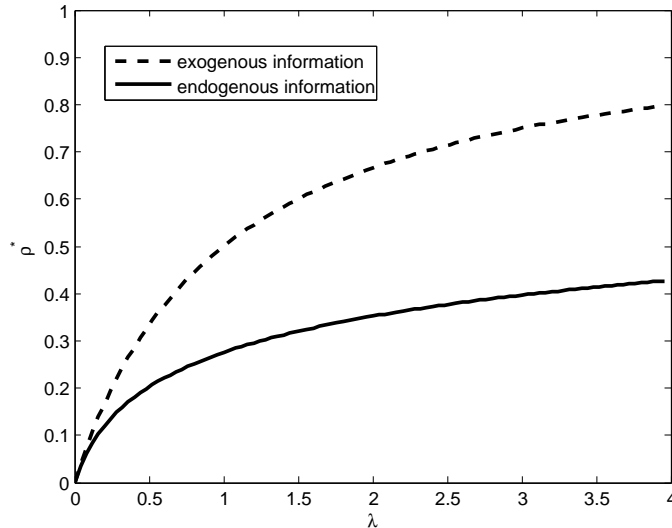


Figure 7: Optimal action ρ^* under full opacity as a function λ for $\sigma_\epsilon^2 = 1$, $\sigma_{\mu,\text{exo}}^2 = 1$, $\sigma_{\mu,\text{endo}}^2 = 1/\gamma_1^2$

4.2 Optimal operational framework

Figure 8 summarises the optimal behaviour of firms γ_1 and γ_2 , the optimal action of the central bank ρ , and the unconditional expected welfare $\mathbb{E}(W)$ in the different operational frameworks under endogenous information.

Accounting for the endogeneity of central bank's information does not alter the relative assessment of frameworks between each other: the same ranking for the different operational frameworks applies as under exogenous information. While taking an optimal action under full opacity in AC yields the highest welfare, taking a fully transparent action in SA delivers the lowest welfare.

However, comparing Figure 1 and Figure 7 shows that the endogenous set-up expands the scope of parameters for which the absence of central bank is superior to the signaling action framework. In particular, the absence of central bank policy yields a higher welfare than taking a signaling action for more realistic parameter combinations, qualifying the critic of Svensson (2006). When welfare equally weights price dispersion and distortion, i.e. when $\lambda = 1$, taking a signaling action is inferior to the absence of central bank even if central bank's observation error σ_η^2 is smaller than that of private firms $\sigma_\epsilon^2 = 1$.

The endogenous nature of central bank's information gives rise to a dilemma for the conduct of monetary policy. While monetary policy aims at influencing the development of the economy, it may at the same time deteriorate the information content of market outcomes, especially when market participants overreact to central bank's disclosure. The dilemma of the central bank consists in choosing an operational framework that allows its policy to stabilise the economy while deteriorating its informative value as less as possible. From a theoretical perspective, taking an optimal action under full opacity is an elegant means of solving this dilemma. In reality, this may not be so easily achieved as policy

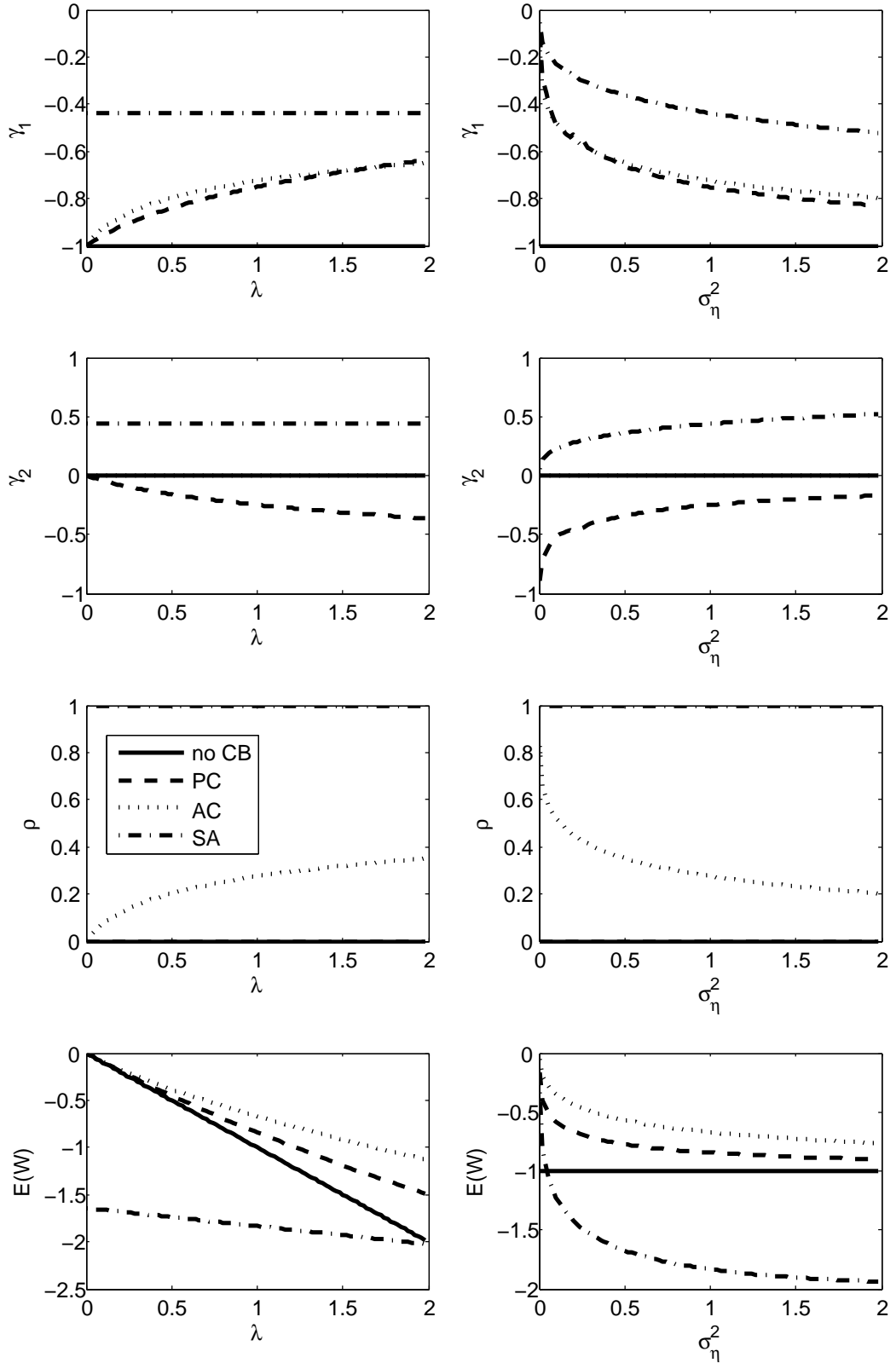


Figure 8: Optimal firms' and central bank's behaviour and unconditional expected welfare under endogenous information as a function of λ and σ_η^2 for $\sigma_\epsilon^2 = 1$, $\xi = 0.15$, $\sigma_\eta^2 = 1$ (left plots), and $\lambda = 1$ (right plots)

actions are typically difficult to hide completely from market participants. However, even if all participants observe the action taken by the central bank, this does not mean that its impact on the economy must necessarily be common knowledge among market participants, as stipulated in the signaling action framework. Between the extreme theoretical cases where the central bank's action is either completely hidden or common knowledge, the central bank has some leeway in designing its operational framework. Maintaining ambiguity on the anticipated impact of its action may contain the degradation of market information, while allowing some stabilisation of the economy.

5 Conclusion

The central bank plays a dual role on the market: while it observes the market to assess economic fundamentals, it also shapes the market outcome through the conduct of monetary policy. A dilemma arises from this dual role because the more effectively the central bank shapes market outcomes, the less reliably market outcomes serve as an indicator of economic fundamentals. The accuracy of central bank's information is thus endogenous to its policy.

This paper has analysed the impact of endogenous central bank's information on the optimal monetary policy in a standard macro-economic model where private agents' behaviour is characterised by strategic complementarities. It focuses on three operational frameworks proposed in the literature: pure communication, action and communication, and signaling action.

Accounting for the endogeneity of information calls for less activism from the central bank. Compared to the exogenous information set-up, endogenous information calls for a higher degree of opacity in the pure communication framework and for a weaker accommodation to shocks in the action and communication framework. Endogenous information also enlarges the range of parameter values for which taking a signaling action delivers a lower welfare than the absence of central bank activism.

While taking an optimal action under full opacity is an elegant way of stabilising the economy without deteriorating the informative value of market prices, it appears difficult to achieve in reality as a policy action is almost impossible to hide from market participants. On the other hand, assuming, as in the signaling action framework, that the impact of a policy action on the economy is necessarily common knowledge may also appear too restrictive. This suggests that the central bank has some leeway in designing its operational framework to minimise the overreaction to its policy action and, thereby, the deterioration of the informative value of market prices. A central bank may thus be well advised to maintain ambiguity around the anticipated purpose of its policy action to prevent spoiling its own information about economic fundamentals.

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