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Hiroki Arato, Takeo Hori and Tomoya Nakamura

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GCOE Secretariat
Graduate School of Economics
OSAKA UNIVERSITY
1-7 Machikaneyama, Toyonaka, Osaka, 560-0043, Japan

Endogenous Information Acquisition and the Partial Announcement Policy*

Hiroki Arato† — *Shinshu University*

Takeo Hori‡ — *Aoyamagakuin University*

Tomoya Nakamura§ — *Osaka University*

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Abstract

We consider implementability and the welfare effects of a partial announcement policy using a model of a beauty contest where agents' actions are strategic complements and where their decisions on public information acquisition are endogenous. The following results are obtained: i) if the authorities sell public information at a constant price, multiple equilibria emerge and a partial announcement equilibrium is unstable; ii) here exist pricing rules that ensure the uniqueness and stability of mixed strategy equilibria, which indicates that a partial announcement policy can be implemented; iii) the optimal price of public information rises as its precision increases relative to private information; iv) the optimal price is independent of the degree of strategic complementarity.

Keywords: Beauty contest games; Endogenous information acquisition; Transparency of information; Partial announcement policy

JEL classification: C73, D82, D83, and E5

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†E-mail address: arato@shinshu-u.ac.jp

‡E-mail address: t-hori@aoyamagakuin.jp

§E-mail address: nakamura@iser.osaka-u.ac.jp

1 Introduction

The authorities provide much information regarding economic fundamentals to the public. This information influences the behavior of market participants. Theoretical literature addresses whether publicly provided information improves social welfare. In their seminal paper, Morris and Shin (2002) show that public information may induce excessive coordination of agents' actions, leading to a detrimental welfare effect if those actions are strategic complements. They conclude that an opaque policy can improve social welfare if the precision of public information is sufficiently low. Many researchers challenge their results.[1] In their influential paper, Cornand and Heinemann (2008) show that a partial-announcement policy, under which the authorities disseminate public information to a certain fraction of agents, can alleviate the problem of excess coordination using the beauty contest model of Morris and Shin (2002). Cornand and Heinemann (2008) conclude that, under an optimal partial announcement, a transparent policy can ameliorate social welfare regardless of the precision of public information.

For policy makers, an important issue is how to pursue a partial announcement policy. If policy makers can know the optimal fraction of public information users and also count the number of users, they could achieve partial announcement by disclosing their information up to the optimal number of users in order of arrival. However, it is not realistic to correctly count up to the level of millions or tens of millions of market participants. Naturally, Cornand and Heinemann (2008) describe plausible methods to exclude some fraction of the agents from acquiring the

[1] James and Lawler (2011, 2012b) strengthen the result of an opaque policy. On the other hand, many researchers show welfare-improving effect of transparent policy, for instance, Hellwig (2002), Angeletos and Pavan (2004), Svensson (2006), Cornand and Heinemann (2008), Dewan and Myatt (2008, 2012), Arato and Nakamura (2011, 2013), and Myatt and Wallace (2014). Moreover, Angeletos and Pavan (2007) and Ui and Yoshizawa (2013) show necessary and sufficient conditions that social welfare is improved by transparent policies in quadratic Bayesian games under incomplete information with normal noises.

information.[2] However, because the fraction of information users is exogenously given in their model, they omit a model-based analysis. In the present paper, we endogenize the fraction of information users and then attempt to design a simple and realistic policy instrument that can achieve the socially optimal partial announcement policy.

To endogenize the fraction of information users, we assume that each agent has to pay a usage fee to acquire public information. If the usage of public information generates a larger payoff than not using public information, an agent decides to pay usage fee and become an information user. As a result, the fraction of information users is endogenized. Using this simple framework, we examine the features of usage fees that implement a partial announcement policy and then characterize the socially optimal usage fee for public information.

Initially, we find that it is not easy for the authorities to implement a partial announcement by selling information at a certain price. When agents' actions are strategic complements, information acquisitions are also strategic complements, as shown by Hellwig and Veldkamp (2009).[3] If the authorities sell public information at a certain price, such strategic complementarity causes multiple equilibria, which consists of two pure strategy equilibria (full- and no-announcement equilibria), and a mixed strategy equilibrium (a partial-announcement equilibrium). The partial-announcement equilibrium is unstable. Hence, unless the authorities could completely coordinate the beliefs of all agents, it would be difficult to realize the partial-announcement equilibrium by selling information at a certain price.

[2]See page 730 in Cornand and Heinemann (2008).

[3]There are other studies regarding endogenous information acquisition in the literature of beauty contest games. Colombo and Femminis (2008) study the model of Morris and Shin (2002) that is extended by introduction of liner cost functions regarding acquisition of signal precisions. Myatt and Wallace (2012) show that the cause of multiplicity as in Hellwig and Veldkamp (2009) is closely related to forms of cost functions regarding information acquisition. Colombo et al. (2013) and Ui (2013) analyze welfare effect of information acquisition under general strategic situations. In contrast to these studies, we focus on stability of a partial announcement equilibrium from a view point of policy implementation.

As shown by Cornand and Heinemann (2008), if the fraction of information users is exogenously given, a partial-announcement policy may alleviate over coordination caused by strategic complementarities. However, our analysis implies that, if each agent faces a decision whether to acquire public information, strategic complementarities caused by the acquisition of public information may disturb the implementation of a partial announcement.

To ensure the uniqueness and stability of the partial-announcement equilibrium, we propose another pricing rule of information. If the authorities offer a pricing rule that counteracts the strategic complementarities of information acquisition, they can coordinate the agents' expectation, and hence, the partial announcement is implementable. One such pricing rule is that the price of public information is sufficiently increasing in relation to the number of public information users. This method involves a strategic substitution effect and makes mixed strategy equilibrium stable.[4]

We next show that there exists the socially optimal usage fee that implements the socially optimal level of publicity. The socially optimal usage fee is determined by the relative precision of public information to private information and the degree of coordination motive. It is shown that, if the relative quality of private information decreases, the optimal degree of publicity and the optimal usage fee increases.

The reason is as follows. The relative worsening of private information accuracy makes the over coordination problem less serious; therefore, the authorities should increase the degree of publicity. Then, the authorities should *increase* the usage fee to *strengthen* the agent's incentive to acquire public information. Such an optimal pricing strategy may seem strange because suppliers who want to increase quantity

[4]Hellwig and Veldkamp (2009) and Myatt and Wallace (2012) also propose the ways to ensure equilibrium uniqueness. They propose the ways to realize a unique pure strategy equilibrium. In contrast, we propose a way to make the mixed strategy equilibrium unique, because the mixed strategy equilibrium corresponds to a partial-announcement one.

sell at a lower price under ordinary economic circumstances. This counterintuitive result comes from the strategic complementarities on information acquisition. The agent's private benefit of public information increases with the number of public information users, and therefore, the market demand curve of public information is upward sloping.

The optimal usage fee is independent of the degree of strategic complementarity. A higher degree of strategic complementarity has two opposite effects. On one hand, the optimal degree of publicity decreases because the excess coordination problem becomes more serious. This effect makes the optimal usage fee lower through the upward-sloping demand curve of public information. On the other hand, the demand curve shifts upward because the private value of public information rises. This effect increases the optimal usage fee. In our model, these two effects cancel one another.

As mentioned above, although Cornand and Heinemann (2008) omit model-based analyses, they describe plausible methods to implement a partial announcement policy. It should be noted that our modeling strategy of endogenizing the fraction of public information users is closely related to one of the methods discussed in Cornand and Heinemann (2008). More specifically, they state that by "selling data at prices that not all agents are willing to pay," the authorities could implement a partial announcement policy. The present study complements the discussion of Cornand and Heinemann (2008) because we provide a model-based analysis of "selling data at prices that not all agents are willing to pay" by extending their model.[5]

[5] James and Lawler (2012a,b) also extend the model of Cornand and Heinemann (2008). Their concerns are different from ours. James and Lawler (2012a) study effects of a partial-announcement policy under heterogeneous precision of private signals. James and Lawler (2012b) analyze a relationship between a partial announcement policy and a stabilization policy in their previous study (James and Lawler, 2011).

Here we briefly discuss why we focus on the method of "selling data at prices that not all agents are willing to pay." We agree that all methods proposed by Cornand and Heinemann (2008) are effective in implementing partial announcement policies. However, other methods (except for the selling of information) raise the question of fairness because these methods may exogenously determine the fraction of information users. For instance, Cornand and Heinemann (2008) state that if the authorities can "launch information in selected media," then they can control the degree of publicity. In this case, market participants who would like to know the policy makers' information may not be given a fair chance to acquire it. Moreover, if policy makers have rights to select media, specific media may be excluded arbitrarily. In comparison with other methods, the method of selling information has advantage of fairness because the authorities can give all the market participants a fair chance to acquire information under equal conditions. Whether to acquire information at the prices displayed then becomes an individual decision for each market participant. Furthermore, under the assumption that the authorities sell public information, we can easily endogenize the fraction of public information users. Thus, the method of selling information is well suited to a model-based analysis of a partial announcement policy.

This paper is organized as follows. Section 2 describes the model, and Section 3 shows the multiplicity of equilibria under certain prices. In Section 4, we present a solution to survive a partial announcement equilibrium. We deal with welfare implications in Section 5. Finally, in Section 6, conclusions are provided.

2 The Model

We borrow our basic model from Cornand and Heinemann (2008). However, departing from their model, we assume that each agent must pay a usage fee to acquire public information.

Payoff structure There are the authorities and a continuum of agents indexed by $i \in [0,1]$. Each agent i chooses an action $a_i \in \mathbb{R}$ to maximize the following payoff:

$$u_i(a,\theta) = \underbrace{-(1-r)(a_i-\theta)^2}_{\text{Loss 1}} \underbrace{-r(L_i-\bar{L})}_{\text{Loss 2}} \underbrace{-T_i+\tau}_{\text{Usage fee}}, \tag{1}$$

where $a \equiv \{a_i : i \in [0,1]\}$ is an action profile, $\theta \in \mathbb{R}$ is an unobservable state, and $r \in (0,1)$ is a parameter that represents the degree of strategic complementarity of action. Loss 1 is a standard loss. Agent i suffers a loss from a distance between a_i and θ. Loss 2 is a beauty contest loss. $L_i \equiv \int_0^1 (a_i - a_j)^2 dj$ indicates that agent i incurs a loss from distances between a_i and others' action a_j. Loss 2 has zero-sum structure because $\bar{L} \equiv \int_0^1 L_j dj$. Agents who use public information are called users and others are called non-users. The share of users is denoted as $P \in [0,1]$. In contrast to Cornand and Heinemann (2008), P is an endogenous variable. The authorities charge a constant usage fee for public information, T, and

$$T_i \equiv \begin{cases} T, & \text{if agent } i \text{ uses public information,} \\ 0, & \text{otherwise.} \end{cases}$$

τ is lamp-sum transfer from the authorities to agents. Financial resource of τ is total fee, $\tau = PT$. From (1), agent i's optimal action is $a_i = (1-r)E_i(\theta) + rE_i(\bar{a})$, where $\bar{a} = \int_0^1 a_i di$ is an average action.

Information structure Information structure is as follows. Assume that all error terms are independent mutually. The state θ is uniformly distributed on $\mathbb{R}$. After nature draws θ, agent i receives a private signal $x_i = \theta + \epsilon_i$ with $\epsilon_i \sim N(0, 1/\beta)$. The authorities also receive a public signal $y = \theta + \eta$ with $\eta \sim N(0, 1/\alpha)$, and disclose it only to users. In this setting, users' and non-users' estimations of θ are $E_{iu}(\theta) \equiv E(\theta|x_i, y) = \frac{\beta x_i + \alpha y}{\beta + \alpha}$ and $E_{in}(\theta) \equiv E(\theta|x_i) = x_i$, respectively.

Timing of the game The game has two stages. At stage 1, agents decide whether to buy the public information, y, given T that is set by the authorities. At stage 2, the authorities disclose y only to the users, and all agents receive x_i and choose a_i.

3 Equilibrium

We solve the model by backward induction.

At stage 2, agents choose their actions, a_i, given T and P. Because of additive separability of our payoff function, each agent's equilibrium action strategy is the same as in Cornand and Heinemann (2008).

Result 1. *The equilibrium action of non-users is $a_{in} = x_i$, and the equilibrium action of users is $a_{iu} = \kappa x_i + (1-\kappa)y$, where $\kappa \equiv \frac{\beta(1-rP)}{\alpha + \beta(1-rP)}$.*

At stage 1, each agent decides whether to use y, given P. Then, expected payoff of user is

$$\begin{aligned} w_{iu}(P) \equiv E[u_{iu}(a)|\theta] = E\Bigg[&- (1-r)(a_{iu} - \theta)^2 \\ - r\left\{ \int_0^P (a_{iu} - a_{ju})^2 dj + \int_P^1 (a_{iu} - a_{jn})^2 dj - r\bar{L} \right\} \Bigg| \theta \Bigg] &- T + \tau \\ = -\frac{(1-rP)(1-\kappa)^2}{\alpha} - \frac{r(1-P) + (1+rP)\kappa^2}{\beta} &+ r\bar{L} - T + \tau, \end{aligned} \tag{2}$$

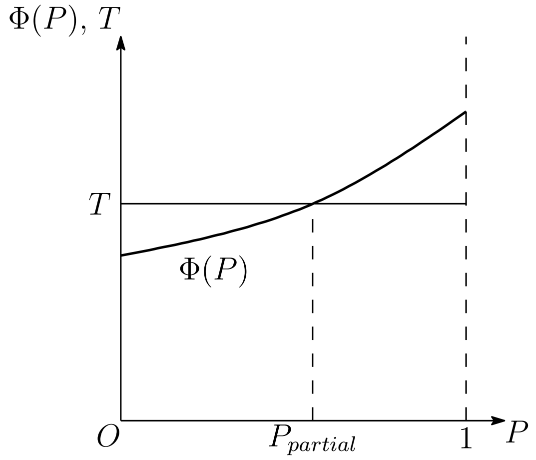

Figure 1: Benefit from acquiring public information

and, similarly, the expected payoff of non-user is

$$w_{in}(P) \equiv -\frac{rP(1-\kappa)^2}{\alpha} - \frac{[1+r(1-P)]+rP\kappa^2}{\beta} + r\bar{L} + \tau. \tag{3}$$

Agent i's problem can be written as $\max_{p_i} p_i w_{iu}(P)+(1-p_i)w_{in}(P)$, where $p_i \in [0,1]$ is a probability that agent i purchases public information. It is the agent i's mixed strategy. From (2) and (3), agent i's net benefit from receiving y is $\Delta w_i(P)$:

$$\Delta w_i(P) \equiv w_{iu}(P) - w_{in}(P) = \frac{\alpha(\alpha+\beta)}{\beta\left[\alpha+(1-rP)\beta\right]^2} - T \equiv \Phi(P) - T,$$

where $\Phi(P)$ represents a gross benefit of acquiring y. If the net benefit is positive, purchasing y is optimal for agent i. If negative, not buying y is optimal. If zero, the two alternatives are indifferent.

Figure 1 represents the cost and benefit of acquiring y. Regardless of P, the cost is constant because T is constant. On the other hand, the gross benefit increases with P; $\Phi'(P) > 0$. This is because the value of public information as a focal point of others' action increases when more agents use y. As a result, the net benefit

$\Delta w_i(P) = \Phi(P) - T$ is strictly increasing in P. Hence, for any $T \in (\Phi(0), \Phi(1))$, there uniquely exists $P_{\text{partial}} \in (0,1)$ such that $\Phi(P_{\text{partial}}) = T$.[6] Then, for all agents, their best response function, $R(P)$, is

$$R(P) \begin{cases} = 0 & \text{if } P < P_{\text{partial}}, \\ \in [0,1] & \text{if } P = P_{\text{partial}}, \\ = 1 & \text{if } P > P_{\text{partial}}. \end{cases} \tag{4}$$

As in Hellwig and Veldkamp (2009), $R(\cdot)$ indicates that public information acquisitions are strategic complements when actions are strategic complements. Public information is useful for inferring other users' actions; hence, when actions are strategic complements, the private value of public information becomes higher as the number of information users increases.

Multiple equilibria and (in)stability A mixed strategy profile, (p_i), is an equilibrium if, for all i, p_i is a best response for the others' strategy profile p_{-i}. From the law of large numbers, $P = R(P)$ holds in a symmetric equilibrium.

We can easily verify that the strategic complementarities about information acquisition cause multiple equilibria. Figure 2 represents the best response when $\Phi(0) < T < \Phi(1)$. $p_i = 0$ ($p_i = 1$) for all i is an equilibrium, because agent i's best response is $p_i = 0$ ($p_i = 1$) for $p_{-i} = 0$ ($p_{-i} = 1$). Moreover, $p_i = P_{partial} \in (0,1)$ for all i, where $P_{partial}$ satisfies $\Phi(P_{partial}) = T$, is also an equilibrium because $p_i = P_{partial}$ is a best response for $p_{-i} = P_{partial}$.

Lemma 1. *Suppose that the authorities apply the constant pricing rule. Then,*

1. *If $T \in (\Phi(0), \Phi(1))$, then multiple equilibria arise as follows.*

   (a) No-announcement equilibrium: $p_i = 0$ for all i, hence $P = 0$,

[6] Partial announcement does not occur when $T < \Phi(0)$ or $T > \Phi(1)$.

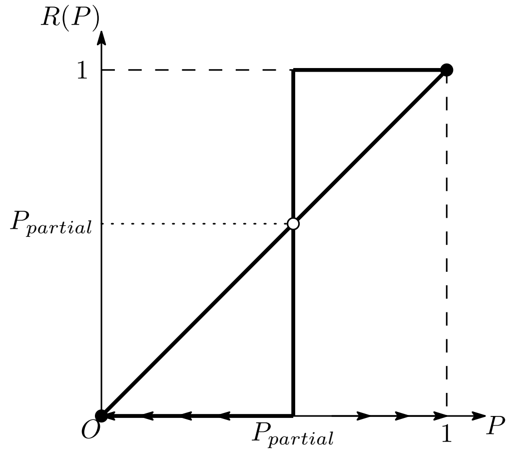

Figure 2: Best response dynamics and (in)stability of equilibrium

(b) Full-announcement equilibrium: $p_i = 1$ *for all* i*, hence* $P = 1$*,*

(c) Partial-announcement equilibrium: $p_i = P_{partial}$ *for all* i*, hence* $P = P_{partial}$*.*

2. *If* $T < \Phi(0)$*, full-announcement equilibrium exists uniquely. If* $T > \Phi(1)$*, no-announcement equilibrium exists uniquely. However, if* $T < \Phi(0)$ *or* $T > \Phi(1)$*, there does not exist any partial-announcement equilibrium.*

Next, we define the stability of an equilibrium, following in the steps of Milgrom and Roberts (1990) and Vives (1990). In what follows, we describe equilibrium by its outcome P_l $(l = 1, 2, 3)$, where $P_1 = 0, P_2 = P_{partial}$, and $P_3 = 1$, correspond to no-announcement, partial announcement, and full-announcement, respectively. A Cournot tatonnement in our game is defined as the process $\{P(t)\}$: $P(0) \in [0, 1]$, $P(t) \in R(P(t-1))$, $t = 1, 2, \cdots$. We define the stability of equilibrium as follows.

Definition 1. *When there uniquely exists an equilibrium, it is stable. When there exist multiple equilibria, an equilibrium* $P_l \in [0, 1]$ *is stable if there exists* $P(0) \neq P_l$ *such that the Cournot tatonnement starting at* $P(0)$ *converges to* P_l*.*

Figure 2 represents the best-response dynamics and equilibrium stability in our information acquisition game. When $P(0) \in [0, P_{\text{partial}})$, the best-response dynamics converges to $P_1(=0)$. When $P(0) \in (P_{\text{partial}}, 1]$, it converges to $P_3(=1)$. Hence, the following proposition holds.

Proposition 1. *Suppose that the authorities apply the constant pricing rule with $T \in (\Phi(0), \Phi(1))$. Then, no-announcement and full-announcement equilibria are stable, and a partial-announcement equilibrium is unstable.*

Such equilibrium instability implies that coordination of the agents' expectation is essential to achieve partial dissemination of public information.

4 A Coordination Device of Expectation

We propose a solution that the authorities guide the agents to the unique partial-announcement equilibrium. The cause of the coordination failure is that, owing to the strategic complementarities, $\Delta w_i(P)$ is upward sloping. To align the agents' beliefs, we employ another pricing rule that has a strategic *substitution* effect. Assume that the fee sufficiently increases in the number of users. Formally, consider a pricing rule $T = \Psi(P)$, where $\Psi(P)$ satisfies that

$$\Psi(P) \begin{cases} < \Phi(P) & \text{if } P < P_{\text{partial}}, \\ = \Phi(P) & \text{if } P = P_{\text{partial}}, \\ > \Phi(P) & \text{if } P > P_{\text{partial}}. \end{cases}$$

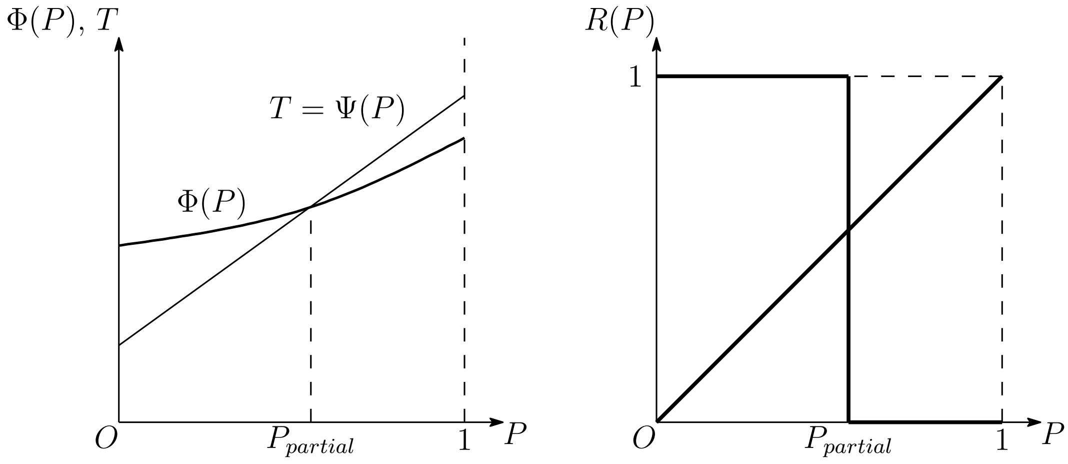

Figure 3: Increasing pricing rule and stability of equilibrium

We call it *an increasing pricing rule*.[7] The strategic substitution effect of $\Psi(P)$ counteracts the strategic complementarities of information acquisition, and makes $\Delta w_i(P)$ downward sloping. Then, the agents plausibly believe that $P = P_{\text{partial}}$ is realized, because the agents' best response function is

$$R(P) \begin{cases} = 1 & \text{if } P < P_{\text{partial}}, \\ \in [0,1] & \text{if } P = P_{\text{partial}}, \\ = 0 & \text{if } P > P_{\text{partial}}. \end{cases} \tag{5}$$

Then, $P = P_{\text{partial}}$ is a unique equilibrium and hence stable (Figure 3).

Proposition 2. *The authorities can implement partial-announcement policy tar-*

[7]In a theoretical viewpoint, $\Psi(\cdot)$ does not need to be continuous. For example, an extreme rule that

$$\Psi(P) = \begin{cases} 0 & \text{if} \quad P < P_{\text{partial}} \\ \Phi(P_{\text{partial}}) & \text{if} \quad P = P_{\text{partial}} \\ \infty & \text{if} \quad P > P_{\text{partial}} \end{cases}$$

satisfies the condition for uniqueness of a partial-announcement equilibrium. However, such a rule may levy a huge payoff loss on all users because of slightly excess demand by accident. Therefore, as to avoid the loss, $\Psi(\cdot)$ should be continuous.

geting $P = P_{partial} \in (0,1)$ by introducing the increasing pricing rule $T = \Psi(P)$ such that:

$$\Psi(P) \begin{cases} < \Phi(P) & \text{if } P < P_{partial}, \\ = \Phi(P) & \text{if } P = P_{partial}, \\ > \Phi(P) & \text{if } P > P_{partial}. \end{cases}$$

5 Welfare Implications

To focus our analysis on feasibility of a partial-announcement policy, we have thus far omitted welfare implications. Thereby, we know that the authorities can achieve any degree of publicity by devising the methods of pricing. However, to maximize social welfare, the authorities should disclose their information only to an optimal fraction of agents by setting T at stage 0. This section studies the welfare implications of a partial announcement and optimal pricing.

5.1 Social welfare and the optimal degree of publicity

We define social welfare as an (normalized) average of individual payoff:

$$W(a|\theta) \equiv \frac{1}{1-r}\int_0^1 u_i di = -\left(\int_0^P (a_{iu}-\theta)^2 di + \int_P^1 (a_{in}-\theta)^2 di\right). \qquad (6)$$

Substituting equilibrium actions (result 1) into (6) yields the following equilibrium social welfare:

$$E[W(a|\theta)] = -P\frac{\alpha + (1-rP)^2\beta}{[\alpha + (1-rP)\beta]^2} - (1-P)\frac{1}{\beta}.$$

Then, if $\alpha/\beta < 3r - 1$, the optimal fraction of user P^* is

$$\frac{\partial E(W)}{\partial P} = \frac{3r(1-r)\alpha(\alpha+\beta)}{[\alpha+(1-rP)\beta]^3}\left(\frac{\alpha+\beta}{3r\beta} - P\right) = 0 \;\Leftrightarrow\; P^* = \frac{\alpha+\beta}{3r\beta} \in (0,1), \quad (7)$$

and if $\alpha/\beta \geq 3r - 1$, $P^* = 1$. This indicates that, if the relative precision of public information is sufficiently low, it is socially desirable that a partial set of agents use public information.[8]

A partial announcement has two effects. First, it limits the number of users. This effect lowers total precision of information in this economy, and it decreases social welfare. Second, it restricts the number of agents who can coordinate through the public information. This effect alleviates the overreaction problem, and it increases social welfare. If public information is sufficiently precise ($\alpha/\beta \geq 3r - 1$), then the second effect is dominated by the first effect. Therefore, $P^* = 1$ maximizes social welfare. On the other hand, if public information has a sufficiently low precision ($\alpha/\beta < 3r-1$), we need to consider tradeoff of the two effects. Then, there exists a socially optimal partial announcement ratio $P^* = (\alpha+\beta)/(3r\beta) \in (0,1)$.

Result 2. *The socially optimal degree of publicity is defined as* $P^* = \min\left\{1, \frac{\alpha+\beta}{3r\beta}\right\}$.

5.2 Optimal usage fee

In this subsection, we determine the socially optimal pricing rules that achieve P^*. First, we consider the case where $\alpha/\beta \geq 3r - 1$, and hence $P^* = 1$. Then, the authorities can maximize social welfare by setting any $T^* < \Phi(0) = \frac{\alpha}{\beta(\alpha+\beta)}$.[9] Next,

[8]This result is identical with that of Cornand and Heinemann (2008).

[9]$T < \Phi(0)$ is a sufficient condition because, from $\Phi'(P) > 0$, if the cost T is smaller than $\Phi(0)$, then it is always optimal for agents to use y. $T^* < 0$ can be understood as subsidies for promotion of using public information.

we examine the case where $\alpha/\beta < 3r - 1$, and hence $P^* = (\alpha + \beta)/(3r\beta)$. Then, by substituting P^* into $\Phi(P)$, we have $T^* = \frac{9\alpha}{4\beta(\alpha+\beta)}$.

Proposition 3. *Given α, β, and r. If the authority defines the usage fee of public information as*

$$T^* \begin{cases} = \frac{9\alpha}{4\beta(\alpha+\beta)}, & \text{if } \alpha/\beta < 3r - 1, \\ < \frac{\alpha}{\beta(\alpha+\beta)}, & \text{if } \alpha/\beta \geq 3r - 1, \end{cases} \tag{8}$$

then P^* is equilibrium.

Combining Propositions 2 and 3 and Result 2, the authorities can achieve a socially optimal partial-announcement equilibrium using the increasing pricing rule $T = \Psi^*(P)$ such that $\Psi^*(P^*) = T^*$ and $\Psi^*(P^*) \gtreqless \Phi(P^*)$ if $P \lesseqgtr P^*$.

Comparative statics We examine properties of the optimal usage fee T^* with respect to the precision of public information α and private information β, and with respect to the degree of strategic complementarity r. The following corollary is derived from Proposition 3.

Corollary 1. *Assume $\alpha/\beta < 3r - 1$. Then,*

$$\frac{\partial T^*}{\partial \alpha} > 0, \quad \frac{\partial T^*}{\partial \beta} < 0, \quad \frac{\partial T^*}{\partial r} = 0.$$

Assume that quality of the authorities' research improves and that they can provide public information with higher precision. The optimal publicity $P^* = (\alpha + \beta)/(3r\beta)$ increases because the excess coordination problem becomes less serious. Then, the authorities should *increase* usage fees to *strengthen* the agent's incentive to acquire public information. At a first glance, such an optimal pricing strategy may seem strange because suppliers who want to increase quantity sell at a lower price under ordinary economic circumstances. This counterintuitive result emerges from the strategic complementarities on information acquisition. The agent's private benefit of public information rises as the number of public information users increases; therefore, the market demand curve of public information is upward sloping.[10]

If the quality of the agents' private information rises, the optimal fraction of public information users decreases. Then the authorities who face an upward-sloping demand curve should lower the usage fees of public information.

Finally, the optimal usage fee is independent of the degree of strategic complementarity. The higher degree of strategic complementarity has two opposite effects. On one hand, the optimal degree of publicity decreases because the excess coordination problem becomes more serious. This effect decreases the optimal usage fee through the upward-sloping demand curve of public information. On the other hand, the demand curve shifts upward because the private value of public information rises. This effect makes the optimal usage fee higher. In our model, these two effects cancel one another.

6 Conclusion

We have analyzed implementability and the welfare effect of a partial-announcement policy by selling public information. A model-based analysis of a public announcement by selling data provides some fruitful policy implications. We obtain the following results.

First, we discover a way to implement a partial announcement policy by selling data. A partial-announcement policy is a solution for alleviating the over coordination problem generated by strategic complementarities in action. However, such

[10]See the left panel of Figure 3.

strategic complementarities transform information acquisition into strategic complements; therefore, any pricing rule that keeps the usage fee constant leads to multiple equilibria. Hence, the strategic complementarities themselves may disturb the implementation of a partial announcement if the authorities sell public information at certain prices. Nevertheless, there is a simple solution to the problem. We show that a partial announcement equilibrium can be unique under some increasing pricing rules that counteract the strategic complementarity of information acquisition; hence, a partial announcement policy is implementable.

Second, we characterize the socially optimal usage fee of public information. If the quality of private information worsens, the authorities should increase the usage fee of public information. The optimal usage fee is independent of the degree of strategic complementarity. These somewhat counterintuitive results originate from the upward-sloping demand curve for public information caused by the strategic complementarities.

There are still some open questions. In our model, the accuracy of private information is exogenous. If private information acquisition is endogenous as in Colombo and Femminis (2008), Colombo et al. (2013), and Ui (2013), then its accuracy depends on the properties of its acquisition cost function, the accuracy of public information, and the degree of strategic complementarities. In this case, the optimal pricing rule on a public announcement might change. This subject is left for future research.

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