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Commitment Not To Learn and Incentives

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This paper explores one reason why decision-makers may prefer to have less information, and why managers choose organization structure that limits the information available to them. The core of this reason is a tradeoff between the value of information and the motivation of employees: subordinates reduce their effort because better information may provoke the leader to choose lower levels of her effort or investment.

The paper presents models of the tradeoff in a symmetric information and signaling game settings, and demonstrates a non-monotonic effect of the information quality on equilibrium profits. Then, it discusses what properties the payoff should satisfy to observe this effect. Finally, the paper studies whether the delegation of authority can eliminate the need to commit not to learn.

Key words: principal-agent, motivation, leadership, commitment

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Настоящая работа изучает возможную причину, из-за которой руководители могут предпочесть иметь меньше информации и выбирать организационную структуру, которая ограничивает информацию, поступающую в их распоряжение. Источником этого явления является компромисс между ценностью информации и мотивированностью подчиненных: последние прикладывают меньше усилий, так как лучшая информированность может спровоцировать сокращение усилий или инвестиций со стороны самого руководителя.

Работа предлагает модель этого компромисса в случае симметричной информации и в случае игры с сигнализированием, и показывает немонотонный эффект качества информации на выигрыши. Также работа обсуждает условия на функции платежей, необходимые для достижения описываемого результата, а также возможность использования делегирования полномочий вместо принятия информационных обязательств.

Ключевые слова: начальник-подчиненный, мотивация, лидерство, обязательства

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1 Introduction

Many organizations or private companies introduce procedures or choose organizational structure that seem to impede receiving information by the upper management, either from the inside or outside. Guides on getting startup funding emphasize that entrepreneurs should not spend effort on estimating the potential size of the business opportunity. Yukos, a Russian oil company which may be considered as an example of transparency and management efficiency in early 2000s, explicitly suppressed new ideas of lower management[1]. Before the arrival of Lou Gerstner, corporate culture at IBM seemed not to reward learning customer needs[2]. So, the choice of informational environment in organizations seems to be endogenous, and should be explained by rational reasons.

The main goal of this paper is to establish that a manager may be willing to commit not to learn valuable information to improve the motivation of her subordinates and increase her profit. Various types of commitments play an important role in many economic models, ranging from employment relationship to political economy. However, informational commitments, that is, commitments not to use or learn some information, are discussed relatively rarely.

The paper considers a joint work of a leader and a subordinate under effort complementarities. Without strategic interaction, additional information available to the leader may cause her optimal effort to decrease, although her profit necessarily rises. Subordinate's motivation concerns may completely change the picture. Under certain conditions, the information negatively affects profits, and in this case the leader may prefer to commit not to get this information.

The first contribution of this paper is a model of a tradeoff between the value of information and the motivation of subordinates to exert effort. Second, it proves that commitment not to learn some valuable information may indeed be made by a rational leader. The paper also discusses the general conditions on the payoff specification and best response functions of the players that produce negative (or, generally, non-monotonic) effect of the information quality. Finally, it shows limitations of the delegation of authority in removing this effect.

The paper is organized as follows. Overview of the related literature will be presented in Section 2. Section 3 presents a simple model with symmetric information, and illustrates the main arguments about informational commitments and the tradeoff between better information and subordinate's motivation. Section 4 develops the argument in a framework of a signaling game, and shows the role of the leader's private information. Next, Section 5 starts a discussion about possible implementations of the commitment not to learn, and explores what can be gained by the delegation of authority. Section 6 concludes.

[1] de Vries, M.K., S. Shekshnia, K. Korotov, E. Florent-Treacy, "The New Russian Business Leaders", pp. 154–155.

[2] Applegate, L., R. Austin, E. Collins, "IBM's Decade of Transformation (A): The Turnaround," HBS Case No. 9-805-130, p. 6.

2 Related Literature

The models in this paper aim to illustrate the ambiguous role of information in a team work setting. Hence, they are related to the broad branch of team work literature. This literature, starting from the seminal paper of Holmström (1982), is frequently focused on the problem of overcoming inefficiency, resulted from the players not fully internalizing the consequences of their actions. This loss of efficiency may be reduced or eliminated using different mechanisms depending on the details of the setup. For instance, if the output but not the effort is contractible, the efficiency can be restored by hiring a risk-neutral principal who will provide full margins to the players. This paper differs from that branch of literature in the first place by its goal: it does not aim at restoring the efficiency, since achieving the first best is very difficult in practice, especially under information asymmetry. Rather, it studies the comparative statics of the (inefficient) equilibria with respect to a parameter describing information quality. The paper analyzes when the profits can decrease with the increased quality of information, and what consequences this may have.

Closer to this work is the branch of literature introducing deeper strategic playing and an asymmetry between the parties. In the model of Rotemberg and Saloner (1993), inefficient decisions by an employee and a CEO emerge as a result of opportunistic playing by the CEO and strategic considerations of the employee. Employee's effort there creates an innovation with some probability less than one. The effort and the success of innovative activities are not contractible, so the employee's incentive payment is conditional on the implementation of the innovation. Deciding whether to implement a successful innovation, the CEO compares its value with the employee's bonus payment, and some NPV positive innovations are not implemented if their value is small relative to the bonus. This possibility is understood by the employee, who recalculates the probability of implementation of the innovations, and demands a higher compensation for his efforts. The CEO's decision rule and employee's demands form a vicious circle, which can result in a hold-up with no innovative efforts. As a way to eliminate the inefficiency, the authors suggest hiring an empathic CEO who will internalize the effect of the implementation decision on the employee's payoff. The model discussed in this paper is close to Rotemberg and Saloner (1993) in its core ingredients, as it also relies upon leader's opportunism and strategic playing by the subordinate. However, it studies a completely different phenomenon related to the role of leader's information, and points to an informational commitment as a way to increase profits.

The question of motivating the subordinates is studied in detail in Hermalin (1998). That paper establishes how a leader can motivate rational agents to exert effort by making sacrifices or exerting high effort herself. The model is set up as follows: a team of players work on a project. The team leader designs the contracts, then learns the state of the world, and participates in the productive activities along with the other team members. The efforts and the state of the world are not contractible, and the contracts can be written on the realized

profit and the leader's announcement of the state of the world. The author shows that the leader can induce higher effort from the other players either by offering higher transfers, or by the means of setting the example of high efforts. This work views the problem of motivating the subordinates from a different angle. Its results show that the anticipation of leader's "shirking" can de-motivate the subordinates, and suggest commitment not to learn as a way to maintain high levels of the subordinate's efforts.

Reviewing other possible remedies for inefficiencies in a leader-subordinate interaction, the due credit goes to Aghion and Tirole (1997), who suggested delegation of authority. This solution is shown to be very powerful when the interests of the leader and the subordinate are imperfectly aligned. Classic papers of Grossman and Hart (1986), Hart and Moore (1990), and later De Meza and Lockwood (1998) and Nöldeke and Schmidt (1998) considered the role of ownership in providing incentives to invest. The main model of this paper assumes unobservable rather than non-verifiable effort, the outside options of the players do not depend on their actions, so re-assignment of ownership rights does not help. The possibility to delegate decision-making rights, on the other hand, raises interesting questions in this framework and is considered in the paper.

The closest paper in terms of addressing inefficiencies is Rotemberg and Saloner (1994), which considered the benefits of narrowing the strategy. In that paper, wider strategy had a demotivating effect on the subordinates in a framework of hold-up issues of two agents competing for limited resources. If two employees work on two different mutually exclusive projects, the prospect of a competitor's success reduces their motivation. Under certain conditions, narrowing the business strategy and abandoning one type of projects turns to be profit-increasing. The models in this paper find motivation issues in a setting with just one agent, and relate them to the quality of information at leader's disposal, rather than the variety of her choices.

In studying the role of information and making its availability endogenous, the important paper is Blanes i Vidal and Möller (2007), which presents ideas complementary to the arguments of this paper. They study how additional information available to the *subordinate* can hurt the leader. The channel of the negative effect of information in the paper is the endogenous leader's bias towards the decisions that her subordinates want to see. In their model, the leader chooses a project using public and private information sources, and the subordinate exerts effort. The quality of the decision and the effort enter the payoff function as complements. In his choice of effort, the subordinate compares the project choice with the available public information, and this produces a bias in the leader's decisions. This creates a tradeoff between the quality of the project choice and the subordinate's motivation. Better public information is found to have an ambiguous effect on profits, and in certain cases the leader is better off restricting the subordinate's access to this information. The negative effect of information can also be alleviated by a self-confidence bias of the leader. Models of this paper are focused on an intriguing question of how and when *leader's* own information may be damaging to her profits. Here, the leader also exerts effort, and it is the possibility of her shirking which negatively

affects the motivation rather than the biases in the decisions. So, this work and Blanes i Vidal and Möller (2007) can be viewed as complements, studying the effects of private and public information via different channels in related settings.

Crémer (1995) also provides an argument why availability of information to the leader, or, more precisely, low acquisition costs, may have a negative effect on her profits. He is motivated by finding that many firms prefer to outsource some activities that can be done in-house, and that many supervisors do not accept excuses for a job not done. The paper argues that better information may make punishment threats less credible, and thus reduce subordinate's efforts. The model can be summarized as follows. The relationship between a principal and an agent lasts for two periods. The agent's productivity depends on his ability, effort, and the realization of an exogenous shock. At the end of the first period, the principal can investigate and learn the ability, effort, and the value of the shock at some cost. If the cost of this information is lowered, i.e., the information becomes better accessible, the principal cannot commit not to investigate ("monitor" in the original terms) in the case of low output, and, in turn, to keep a high-ability agent who exerted low effort in the first period. The increased protection from being fired weakens the agent's incentives. Models presented in this paper study a different channel of the influence of information availability on profits: anticipation of leader's shirking by the agent. They are not tied to hiring and firing decisions, and find the ambiguous effect of information in a one-period setting. Thus, they are applicable to a wider range of situations, such as relationships between a CEO and firm's departments, or even between separate entities. Setup chosen for the basic model of this paper also has the benefit of simplicity.

3 Illustrative Model

As a first step, this section will present a stylized model showing an ambiguous role of information in leader's profits. Certainly, this model will not be able to illustrate all the questions studied in this paper. Nevertheless, it will show the basic tradeoff between the leader's information and the motivation of her subordinates, and provide intuition to the subsequent results of the paper.

3.1 Symmetric Information Model

Setup

Two players in the model are a leader and a subordinate, who want to implement a project. Leader's effort will determine the probability of success, and the subordinate's effort determines the revenue from the project conditional on its success.

More specifically, the project may succeed on its own with probability p, and leader's effort $y \in [0, 1]$ creates an additional chance for the project to succeed with probability y. Overall, the probability of success is $y + (1 - y)p$, and the cost of leader's effort is $\frac{y^2}{2k}$. Parameter $p \in [0, 1]$ of

the model will be interpreted as the quality of information in leader's possession, and Section 4 will provide a justification for this interpretation.

Subordinate's effort $x \geq 0$ generates revenue equal to x if the project succeeds, and costs $\frac{x^2}{2c}$ in any case. The leader and the subordinate get shares α and $1-\alpha$ of the revenue, respectively. So, the expected payoffs of the players are

$$\Pi_L = \alpha\left[y + (1-y)\,p\right]x - \frac{y^2}{2k},$$
$$\Pi_S = (1-\alpha)\left[y + (1-y)\,p\right]x - \frac{x^2}{2c}.$$

This specification of the payoffs implies that the leader's effort and information quality are substitutes, and leader's and subordinate's efforts are complements. The form of the payoff function is discussed more in the next subsection. The efforts of the players are not contractible, and are chosen simultaneously.

Note that the assumption about the way of dividing the revenue is not restrictive. It may be interpreted as a bargaining game (with effort costs already sunk), and in this case parameter α will represent the bargaining power. Alternatively, it may be assumed that the revenue from the project may in fact take only two values, 0 or V, and effort x determines the probability of a realization of the high value. Then, under limited liability assumption, any contract between the leader and the subordinate will be a revenue-sharing one.

Equilibrium

The equilibrium in this game can be characterized as follows.

Lemma 1. *If $\alpha(1-\alpha)kc \leq 1$, the equilibrium is $y \equiv 1$, $x \equiv (1-\alpha)c$ for all p. Otherwise, for $p \leq 1 - \frac{1}{\alpha(1-\alpha)kc}$, the equilibrium efforts are*

$$y = 1, \qquad x = (1-\alpha)c,$$

and for $p > 1 - \frac{1}{\alpha(1-\alpha)kc}$,

$$y = \frac{\alpha(1-\alpha)kcp(1-p)}{1-\alpha(1-\alpha)kc(1-p)^2}, \qquad x = \frac{(1-\alpha)cp}{1-\alpha(1-\alpha)kc(1-p)^2}.$$

The main result of this model is related to the effect of information quality p on profits.

Proposition 1. *Assume $\alpha(1-\alpha)kc > 1$. Then,*

1. *leader's profit in equilibrium is not monotonic in p: it remains constant for $p \leq 1 - \frac{1}{\alpha(1-\alpha)kc}$, decreases in a non-trivial range $1 - \frac{1}{\alpha(1-\alpha)kc} < p < \tilde{p}$, and increases for $\tilde{p} < p < 1$;*

2. *in a non-trivial range $1 - \frac{1}{\alpha(1-\alpha)kc} < p < \bar{p}$ leader's profit is less than at $p = 0$.*

Figure 1: Leader's profit as a function of p

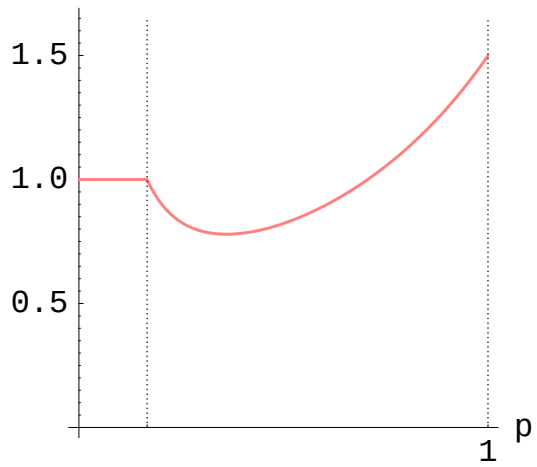
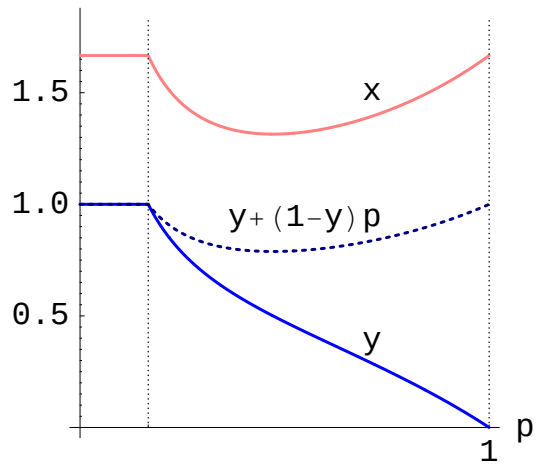


Figure 2: Efforts as functions of p



The profit curve illustrates the conclusions of Proposition 1: non-monotonicity of the profit, and the existence of a range of p where the profit is lower than at $p = 0$. The picture is drawn for $\alpha = \frac{9}{10}$, $k = 1$, $c = \frac{50}{3}$.

A typical picture leader's payoff and player's efforts is shown on Figures 1–2. These figures illustrate that a drop in subordinate's effort may cause leader's profit decrease. So, there exists a tradeoff between the direct benefits of having better information, and the motivation of the subordinate to exert his effort.

Now, suppose that before the game starts, the leader has a choice whether to get information of quality p or not ($p = 0$). Proposition 1 suggests that in some cases the leader will prefer to not to have information and make a commitment not to learn it. This observation is the essential result of the paper, and it will be derived again and expanded in the main model of Section 4.

3.2 Sources of the Negative Effect of Information

Before proceeding further, it is worth discussing what are the underlying reasons for the observed decline of the leader's profit.

This effect can be traced to the properties of the payoff function: substitution between effort and information quality, and complementarities of efforts. Intuitively, when the quality of information improves, the leader tends to decrease her effort. Holding subordinate's effort constant, this effort decrease cannot lead to decreasing profits. However, the presence of the subordinate works as an amplifier because of effort complementarities, so in *equilibrium* the leader's profit drops.

The effect of the subordinate's strategic playing can be shown in a more general setting.

Suppose, the payoffs of the players are given as

$$\begin{cases} \Pi_L = \alpha\left[y\,U(x) + (1-y)\,u(x,p)\right] - \dfrac{y^2}{2} \\ \Pi_S = (1-\alpha)\left[y\,U(x) + (1-y)\,u(x,p)\right] - x, \end{cases} \tag{1}$$

where $y \in [0,1]$ is the leader's effort, and $x \geq 0$ is the subordinate's one (normalized to its cost), and p is the quality of leader's information. First, assume standard properties of the production functions, $U(0) = 0$, $U' > 0$, $U'' < 0$, $u(0,p) = 0$, $u'_x > 0$, $u''_{xx} < 0$. Note that under additional assumption $u'_p > 0$, this specification implies that the information quality and leader's effort are substitutes. Also, assume $u(x,0) = 0$, $u(x,1) \geq U(x)$, and $U' - u'_x > 0$ for all $p < 1$. The last one states that the leader's and subordinate's efforts are complements. For example, $u(x,p) = U(x)p$ and any standard production function $U(x)$ like $U(x) = \sqrt{2cx}$ will satisfy all of these assumptions.

The internal solution for best responses of the players is determined from

$$\begin{cases} y = \alpha\left(U(x) - u(x,p)\right) \\ y\,U'(x) + (1-y)\,u'_x(x,p) = \dfrac{1}{1-\alpha}, \end{cases} \tag{2}$$

and can be written as

$$\begin{cases} y = f(x,p) \\ x = h(y,p). \end{cases}$$

Suppose there exists $p_0 \in (0,1)$ such that the equilibrium leader's effort $y^* = 1$ for $p \leq p_0$ and $y^* < 1$ for $p > p_0$. For this, it is sufficient that

$$U\left((U')^{-1}\left(\frac{1}{1-\alpha}\right)\right) > \frac{1}{\alpha}. \tag{3}$$

For $p \geq p_0$ the equilibrium efforts are

$$\begin{cases} y = f(h(y,p),p) \\ x = h(f(x,p),p), \end{cases}$$

and they depend on p as

$$\begin{cases} \dfrac{dy}{dp} = \dfrac{f'_x h'_p + f'_p}{1 - f'_x h'_y} \\ \dfrac{dx}{dp} = \dfrac{h'_y f'_p + h'_p}{1 - f'_x h'_y}. \end{cases}$$

It can be noted that $f'_x > 0$, $h'_y > 0$, $f'_p < 0$. Also, $h'_p = 0$ at $p = p_0$. So, the sign of the derivatives $\frac{dy}{dp}$ and $\frac{dx}{dp}$ depends on how $f'_x h'_y$ compares with one. If $f'_x h'_y < 1$, the equilibrium efforts of both players decrease in p at $p = p_0$, and so does the leader's profit (since $\frac{\partial \Pi_L}{\partial y} = 0$

and $\frac{\partial \Pi_L}{\partial p} = 0$ at $p = p_0$).

In the payoff specification from Subsection 3.1, condition $f'_x h'_y < 1$ holds automatically at $p = p_0$ as long as $p_0 \in (0, 1)$. Hence, the assumption of Proposition 1 is just a re-statement of condition (3).

This discussion suggests that the negative impact of information quality on leader's profit is not a peculiarity, but a natural consequence of the interaction between efforts and information quality in the payoff function. So, this effect may be expected in a variety of models as long as there are complementarities between players' efforts and substitution between effort and information.

Complementarity of efforts is a natural and standard assumption, especially after postulating that the leader controls the probability of success, and the subordinate's effort determines the payoff. Substitution between effort and information quality implies that the leader in her efforts aims at some "binary" result, which is just achieved or not, and there is limited upside in her efforts. The examples of this kind of leader's activities are attracting funding, or making a single non-recurrent sale, where there are no benefits from any extra effort once the result is obtained.

4 Information in a Signaling Game

4.1 Signaling Game Model

This subsection will present the main model of the paper. It will show how the increasing quality of *private* information of the leader may be detrimental for her profits, and that sometimes the leader may indeed be willing to commit not to learn it.

Setup

A leader and a subordinate face two projects, A and B, and may implement only one of them; the leader has the authority to decide which one. There is an uncertainty about project success, however, leader may make an investment which ensures success of any project she chooses. The subordinate supplies effort which determines the payoff in the case of success.

One of the projects is good and will always succeed, the other one succeeds only if the leader makes the investment. The identity of the good project is not known, and the prior probability is 1/2. The leader and the subordinate observe a public signal s_p about project qualities of precision $q > 1/2$, and the leader additionally observes a private signal s_L of precision p which is independent from the public signal. Successful project generates expected revenue $a + x$, where $x \geq 0$ is the subordinate's effort which costs $\frac{x^2}{2c}$. The leader's investment decision is binary, $y \in \{0, 1\}$, and the investment cost is k. Thus, for each realization of signals the expected total revenue is

$$W(s_L, s_p) = \Big(y + (1 - y)\Pr[\text{success}|\hat{\theta}, s_L, s_p]\Big)(a + x(\hat{\theta}, s_p)),$$

where $\hat{\theta} = \hat{\theta}(s_L, s_p)$ denotes leader's choice of the project. The leader and the subordinate get shares α and $1-\alpha$ of the revenue, respectively, and bear their costs:

$$\Pi_L = \alpha W - yk,$$
$$\Pi_S = (1-\alpha)W - \frac{x^2}{2c}.$$

As discussed in Subsection 3.1, the assumption about the way the players divide the revenue is not restrictive. Similar to the model of that subsection, leader's effort and information quality are substitutes, whereas efforts of the leader and the subordinate are complements. These properties of the payoff function specification is key to the results of this paper.

Assume the following timing:

1. the leader makes the investment or abstains,
2. the leader and the subordinate observe the signals as described above,
3. the leader announces her decision which project to implement,
4. the subordinate exerts his effort, the payoffs are realized.

The investment and effort decisions of the players are not observable, and the project choice is not contractible.

In this game, the strategy of the subordinate is formally a function of the leader's decision $\hat{\theta}$ and the public signal s_p. However, his effort in fact depends only on whether the leader's choice matches the public signal. So, the expected payoff of the subordinate

$$\begin{aligned}\mathrm{E}\Pi_S = (1-\alpha)\Big[&\Big(y + (1-y)\Pr[\,\theta = \hat{\theta}\,|\,\hat{\theta} \neq s_p\,]\Big)(a + x_0)\Pr[\,\hat{\theta} \neq s_p\,] + \\ &\Big(y + (1-y)\Pr[\,\theta = \hat{\theta}\,|\,\hat{\theta} = s_p\,]\Big)(a + x_1)\Pr[\,\hat{\theta} = s_p\,]\Big] - \\ &\frac{x_0^2}{2c}\Pr[\,\hat{\theta} \neq s_p\,] - \frac{x_1^2}{2c}\Pr[\,\hat{\theta} = s_p\,],\end{aligned}$$

where θ denotes the true identity of the good project, $\hat{\theta} = \hat{\theta}(s_L, s_p)$ again denotes the leader's choice, and x_1 and x_0 are subordinate's efforts for the cases of a match and a mismatch of the leader's decision and the public signal. Similarly, the expected payoff of the leader

$$\begin{aligned}\mathrm{E}\Pi_L = \alpha\Big[&\Big(y + (1-y)\Pr[\,\theta = \hat{\theta}\,|\,\hat{\theta} \neq s_p\,]\Big)(a + x_0)\Pr[\,\hat{\theta} \neq s_p\,] + \\ &\Big(y + (1-y)\Pr[\,\theta = \hat{\theta}\,|\,\hat{\theta} = s_p\,]\Big)(a + x_1)\Pr[\,\hat{\theta} = s_p\,]\Big] - yk.\end{aligned}$$

The subsequent analysis will be focused on the effect of the quality of leader's private information, p, on her payoffs in equilibrium.

Equilibrium

To observe a non-trivial effect of information quality p on equilibrium strategies and payoffs, it is necessary to make certain assumptions about model parameters.

The most critical assumption is the following.

Assumption A1. *The investment cost is not too large, namely,*

$$k < \alpha(1-q)(a + (1-\alpha)c).$$

It states that the effort cost for the leader is sufficiently small so that she prefers to make the investment if she does not have private information or if its quality is low ($p = 1/2$ or close).

To simplify the description of equilibria, I will be using a stronger assumption.

Assumption A2.

$$k < \alpha(1-q)(a + q(1-\alpha)c).$$

This one guarantees that the leader's strategy not to invest and follow the public signal (when it contradicts to her private one) is neither an equilibrium nor a profitable deviation for all values of $p \in [1/2, 1]$ and for any levels of subordinate's effort which may arise in equilibria.

Proposition 2. *Under assumption (A2) there exist thresholds of leader's private information quality $q < p_d < p_i < 1$, $q < p_{ni} < p_i$, such that all the sequential equilibria of the game satisfying D1 criterion of Cho and Kreps (1987) can be characterized as follows.*

1. *For $1/2 \le p \le p_d$, the leader's strategy to invest dominates the alternatives. She chooses $y = 1$, follows her private signal, and the subordinate exerts effort $x = (1-\alpha)c$ regardless of the project choice. In this range of p, there are multiple equilibria with different project choice strategies of the leader; however, all of them lead to the same payoffs for the players.*

2. *For $p_d < p \le p_i$, the leader chooses to invest, $y = 1$, follows the public signal in her project choice, and the subordinate chooses efforts*

$$\begin{aligned} x_1 &= (1-\alpha)c, && \textit{if the leader's decision matches the public signal,} \\ x_0 &= \frac{p(1-q)(1-\alpha)c}{p(1-q) + (1-p)q}, && \textit{otherwise.} \end{aligned}$$

3. *For $p_{ni} \le p \le 1$, the leader does not invest, $y = 0$, follows her private signal, and the subordinate exerts efforts*

$$\begin{aligned} x_1 &= \frac{pq(1-\alpha)c}{pq + (1-p)(1-q)}, && \textit{if the leader's decision matches the public signal,} \\ x_0 &= \frac{p(1-q)(1-\alpha)c}{p(1-q) + (1-p)q}, && \textit{otherwise.} \end{aligned}$$

4. *For $p_{ni} < p < p_i$ there is also a mixed-strategy equilibrium in which the leader and the subordinate mix the strategies of equilibria 2 and 3 above.*

This characterization implies that for $p_{ni} < p < p_i$ there are three distinctive equilibria, two in pure strategies and one in mixed strategies.

The proof of this proposition is delegated to the Appendix.

Equilibrium Profit

Most important for the purpose of this paper are the properties of leader's profit in equilibrium with respect to changes of parameter p.

A typical picture of the profit as a function of p is presented on Figure 3.

Proposition 3. *Under assumption (A2) there exist a non-trivial range $(p_i, \tilde{p})$ where leader's profit is less than what she would get if she had no private information (p were $1/2$).*

Proof. First, the leader's payoff in type-2 equilibrium of Proposition 2 at $p = p_i$ is equal to her profit at $p = 1/2$.

Fix $p = p_i$. Key part of the proof is to see that the profit in type-3 equilibrium is lower than in type-2 one. Denote by (x_0^{ni}, x_1^{ni}) and (x_0^i, x_1^i) the subordinate's strategies in these two equilibria; also, denote by $m = 1$ leader's strategy to follow the private signal, and by $m = 0$ to follow the public one. Observe

$$\Pi_L(m = 0, y = 1, x_0^i, x_1^i) \geq \Pi_L(m = 1, y = 0, x_0^i, x_1^i) > \Pi_L(m = 1, y = 0, x_0^{ni}, x_1^{ni}).$$

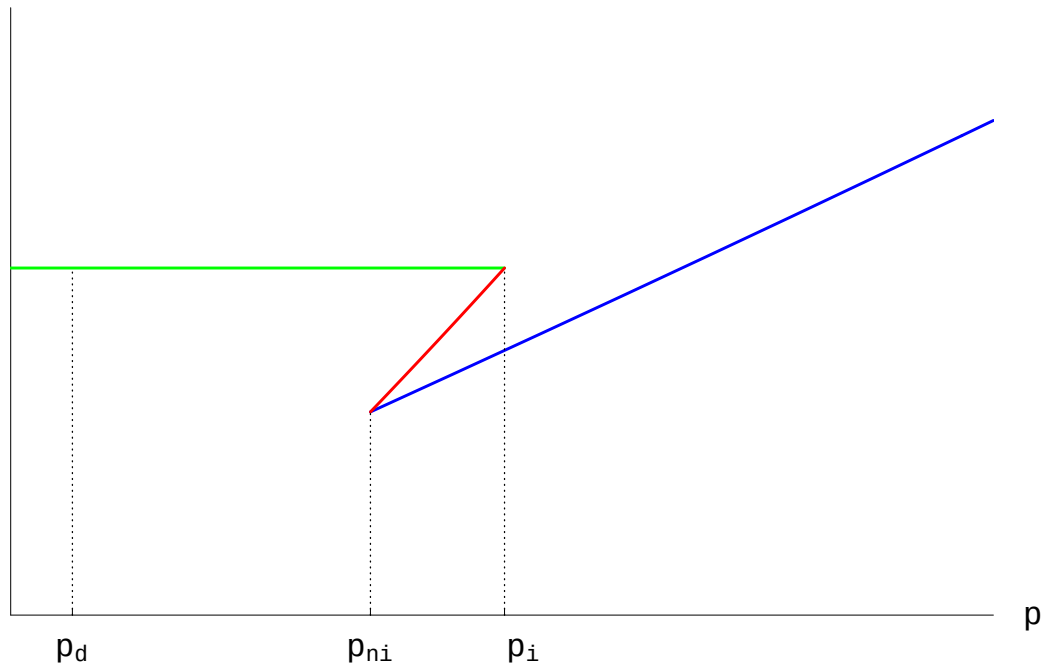
The first inequality holds by the virtue of $(m = 0, y = 1, x_0^i, x_1^i)$ being an equilibrium, and the second inequality holds because $x_1^i > x_1^{ni}$, $x_0^i = x_0^{ni}$, and the leader's profit is strictly increasing in subordinate's efforts when $y = 0$.

For $p > p_i$, type-3 is the only equilibrium surviving D1 refinement. By continuity, the leader's profits will be lower than the ones in type-2 equilibrium in some neighbourhood of p_i. □

The intuition of this result is related to the possible opportunistic behavior of the leader. When she invests, the subordinate's effort levels are higher. So, the strategy to invest ceases to be incentive compatible for her earlier than the level of signal quality at which the value of investment equals its cost.

This proposition establishes the result similar to the one of Section 3: information may hurt leader's profits, which implies that the leader may be willing to commit not to learn it.

Figure 3: Leader's profit as a function of the private signal quality p



The left segment corresponds to leader's investment, and the project choice is irrelevant in this case. The right segment corresponds to leader not making the investment, and following his private signal. The middle segment is a mixed-strategy equilibrium. The important observation is that p_{ni} is always less than p_i, and there is a drop in equilibrium profits for p just above p_i in comparison with what was available for $1/2 < p < p_{ni}$. The picture is drawn for $\alpha = 1/2$, $a = 2$, $c = 4$, $q = 3/4$, $k = 3/7$.

4.2 Multiple Subordinates

The model presented in the previous subsection can be extended to the case of multiple subordinates in the following way.

Model

Suppose the leader has N subordinates and two lines of business; only one line may be pursued. Any chosen line will be successful if she makes an investment (which costs Nk). Without the investment, only one is potentially successful, so the leader needs to guess right. *A priori*, the business lines are symmetric. Each subordinate gets a signal of precision q which line is potentially successful, and these signals are observed by the leader (but not by the other subordinates). On top of that, the leader gets her own private signal of precision p. Conditional on the success of the chosen business line, each subordinate generates the expected revenue $a + x_i$, where x_i is his effort. The revenue is shared between the leader and the subordinates. So, subordinate i gets the expected payoff $(1 - \alpha)(a + x_i)$ conditional on the success of the business line, and bears costs $\frac{x_i^2}{2c}$ in any case. The leader gets share α of all revenues, and bears investment costs.

This setup leads to results similar to the single-subordinate case.

Proposition 4. *For sufficiently small k, $k < k(a, c, \alpha, q, N)$, the leader's profit is not monotonic in p. Moreover, in a non-trivial interval $p \in (\underline{p}, \overline{p})$ the leader's profit is lower than at $p = 1/2$.*

A typical picture of the leader's profit as a function of p is presented on Figure 4.

The effect of the number of subordinates

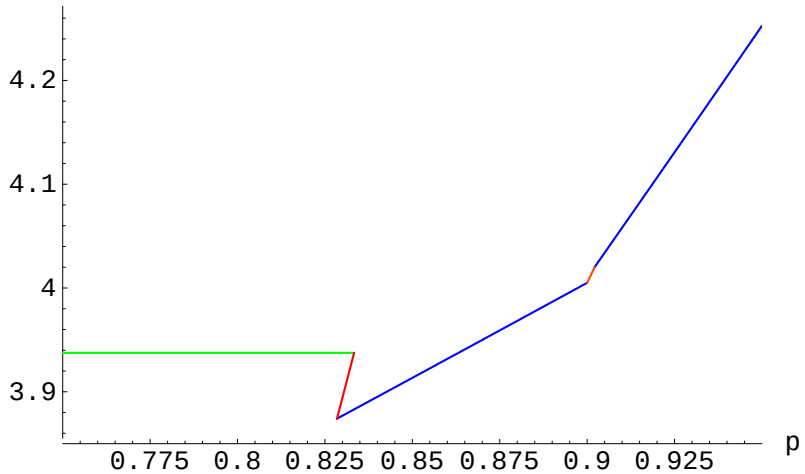
Next, it is possible to investigate the effect of increasing the number of subordinates on the information–motivation tradeoff and the need to commit not to learn.

Proposition 5. *Holding other parameters fixed, for sufficiently large N the leader's profit becomes monotonic in p.*

The source of this result is the property of the multi-subordinate model with respect to the overall quality of information available to the decision-maker. Holding other parameters fixed, the increase in the number of subordinates makes the analogue of Assumption (A1) fail. Indeed, each new subordinate gets his own signal about the projects, and increases the information at leader's disposal; better information, in turn, makes investment less profitable. If the leader never invests, the goals of the leader and the subordinates become better aligned, the subordinates have no incentives to reduce their effort in fear of leader's opportunism, and the profit becomes monotonic.

The discussion above suggests that the key assumption in this setting is the one about the increasing information availability when the number of subordinates grows. From this point

Figure 4: Leader's profit as a function of the private signal quality p, $N = 2$



This picture can be compared with Figure 3. The main three segments from left to right represent: leader's investment, no investment and majority project choice rule, no investment and following the private signal rule. They are connected by mixed-strategy equilibria. Similar to one-subordinate models, there is a profit drop at the point where the leader's strategy to invest ceases to be an equilibrium. The picture is drawn for $\alpha = 1/2$, $a = 2$, $c = 4$, $q = 3/4$, $k = 9/32$.

of view, the results of this subsection are more applicable when a “subordinate” represents a distinct department within an organization, rather than an individual employee.

5 Commitment Devices

The main point of this paper has been an argument that the leader may find it beneficial to commit not to learn. The next naturally arising question is what instruments she may use to implement it. This question opens an important direction of further development of the ideas of the paper, which deals with how the tradeoff between information and motivation, as well as the need to commit not to learn, affect the structure of the organization. The first step in this direction will be the analysis of the possibility of the delegation of authority.

5.1 Delegation

The basic intuition of the seminal paper Aghion and Tirole (1997) is that the authority should belong to the party for which it has the highest importance. Additionally, in the setup of this paper, the delegation of the right to choose the project to the subordinate will separate authority and information. So, there might be reasons to believe that delegation can cure the negative effect of the increasing information quality, and improve profits at least for some values of parameters.

Surprisingly, delegation appears to be not as helpful as it might seem to be, and the main obstacle is the possibility to renegotiate.

More formally, suppose the leader has an option to transform the game of Subsection 4.1 into the following process:

1. the leader makes the investment or abstains,
2. the leader and the subordinate get signals: both of them observe a public signal, and the leader additionally observes a private one,
3. the subordinate decides which project to implement,
4. the leader and the subordinate can communicate (or renegotiate),
5. the subordinate exerts his effort, the payoffs are realized.

It will be assumed that any surplus from renegotiations at stage three will be divided in the same proportion α to $1-\alpha$ as the total revenue, i.e., that the bargaining power of the parties does not depend on what type of revenue they divide. This assumption will make the cases of leader's and subordinate's authority directly comparable.

The main question is whether under subordinate's authority the parties will be able to reach the efficient decision (to follow leader's private signal) for high values of p, and whether they can avoid profit drop at $p = p_i$.

The first result is the following.

Proposition 6. *Under assumptions of Proposition 2 and subordinate's authority,*

- *strategies of the leader to invest, the subordinate to follow the public signal and exert effort $x = (1-\alpha)c$, continue to form an equilibrium for $p \leq p_i$;*

- *strategies of the leader not to invest, tell the subordinate her private signal, and the subordinate to follow this message and exert efforts*

$$x_1 = \frac{pq(1-\alpha)c}{pq + (1-p)(1-q)}, \qquad \textit{if the leader's message matches the public signal,}$$
$$x_0 = \frac{p(1-q)(1-\alpha)c}{p(1-q) + (1-p)q}, \qquad \textit{otherwise}$$

  continue to be an equilibrium for $p \geq p_{ni}$;

- *for $p > p_i$, the strategies of the leader to invest, the subordinate to follow the public signal and exert effort $x = (1-\alpha)c$, are not a sequential equilibrium satisfying D1 criterion in a game with renegotiations.*

The proof of this proposition will be given in the Appendix.

This proposition shows that the players can replicate the equilibria of the original game with leader's authority. The leader can persuade the subordinate to make the efficient decision by a cheap talk when she has high-quality information. At the same time, for lower values of information quality, she can also persuade the subordinate to change his decision if she deviated not to invest. This destroys one possible equilibrium with leader's investment and high subordinate's effort for $p > p_i$.

The crucial condition for this result is the ability of the leader to renegotiate *after* the subordinate has chosen a project. The outcome of the game may be different if the subordinate may randomize his choice and if renegotiations are allowed only before the subordinate announces the decision.

6 Conclusion

In this paper I considered the role of information in the framework of a team work of a leader and a subordinate under the assumption of effort complementarity. Models with either symmetric or asymmetric information show that the quality of leader's information has an ambiguous effect, and the increased quality may cause a decline of her profits. The source of this effect is the motivation of the subordinates: better information increases leader's incentives to act opportunistically, and that lowers subordinates' efforts. Consequently, the leader may find it beneficial to commit not to learn otherwise useful information.

In practice, the ways to implement this commitment may vary. One of the ways for a CEO to show that she does not get project ideas from sources outside of the company is to establish a procedure that outsiders cannot arrange a meeting with the CEO directly. Any meeting with an outsider should be organized by a vice president or other CEO's subordinate, who may insist on listening the outsider's proposal first. The CEO may be willing to agree to the arrangements effectively creating barriers for outsiders, because such arrangements improve management's

motivation. This paper presents an explanation of such barriers besides the concerns about the efficient use of such a scarce resource as the CEO's time.

The paper questions the possibility to implement the commitment through the delegation of decision-making rights. However, I find that the delegation does not work this way and cannot eliminate the profit drop if the leader is allowed to renegotiate.

The other direction of thinking about commitment implementation is related to the hierarchical structure of organizations. Vertical hierarchies and implementation of commitments by choosing the organizational structure are the directions to continue this research.

Appendix

Proposition 2

Proof. To prove the proposition, I will first consider the strategies which may be played in an equilibrium and find the corresponding range of the values of parameter p. Then, I will show that all other strategies can be excluded by domination.

1. Consider the strategy of investing ($y = 1$) and choosing the project arbitrarily, yielding subordinate's best response $x = (1 - \alpha)c$. It forms an equilibrium when

$$\Pi_L = \alpha(a + (1 - \alpha)c) - k \geq \alpha \max(p, q)(a + (1 - \alpha)c), \tag{4}$$

which can be reduced under Assumption (A2) to

$$p \leq 1 - \frac{k}{\alpha(a + (1 - \alpha)c)} = p_d. \tag{5}$$

Note that Assumption (A2) guarantees that $p_d > q$.

2. At $p = p_d$, the binding restriction in the previous equilibrium is related to the leader mixing in the strategy of following her private signal. So, consider the pure strategy of investing ($y = 1$) and following the public signal ($m = 0$).

On the equilibrium path, the subordinate's best response is again $x_1 = (1 - \alpha)c$. The critical element of this equilibrium is the effort out of the equilibrium path, x_0, when the leader's choice does not match the public signal[3]. If $p \leq p_d$, subordinate's beliefs out of the equilibrium path cannot be effectively restricted, so this range of the values of parameter p gives many equilibria with different values of effort level x_0. For $p > p_d$, the leader's type that benefits most from the deviation is the type $y = 0$, $m = 1$ (abstain from investing and follow the private signal), and this point will be formally analyzed below. Hence, the subordinate's effort in the case of a mismatch of the leader's choice and the public signal will be $x_0 = \frac{p(1-q)(1-\alpha)c}{p(1-q)+(1-p)q}$. The no deviation conditions for the leader will

[3]The strategies of the players are specified here in terms of a match or a mismatch of the signals, and ignore the identity of the projects. This specification is not restrictive. Because of prior symmetry of the projects, the strategies and all the subsequent inequalities can be interpreted as conditional on a particular realization of the public signal.

look like

$$\alpha(a+x_1)-k \geq \alpha q(a+x_1) \qquad (y=0, m=0), \tag{6}$$

$$\alpha(a+x_1)-k \geq \alpha\left(a+x_1 \Pr[\theta=s_p,]+x_0 \Pr[\theta \neq s_p]\right)-k \qquad (y=1, m=1), \tag{7}$$

$$\alpha(a+x_1)-k \geq \alpha p\Big(a+x_1 \Pr[\theta=\hat{\theta}, \theta=s_p]+ x_0 \Pr[\theta=\hat{\theta}, \theta \neq s_p]\Big) \qquad (y=0, m=1). \tag{8}$$

The first one holds because of Assumption (A2), the second one since $x_1 > x_0$. So, the strategy $(y=1, m=0)$ is an equilibrium satisfying D1 criterion when condition (8) holds. This condition can be translated into a quadratic inequality on $p \in [\frac{1}{2}, 1]$, which solution is $\frac{1}{2} \leq p \leq p_i$ for some $p_i \in [\frac{1}{2}, 1]$. Since $x_0 < x_1$, comparison of (4) with (8) gives $p_i > p_d$.

The only missing detail in this part of the proof is the comparison of leader's types, which should yield the restrictions on the beliefs out of the equilibrium path. Following Cho and Kreps (1987), define

$$D_t = \left\{\phi \in MBR_S : \Pi_L^*(t) < \sum_r \Pi_L(t,r)\phi(r)\right\}$$

$$D_t^0 = \left\{\phi \in MBR_S : \Pi_L^*(t) = \sum_r \Pi_L(t,r)\phi(r)\right\},$$

where t denotes leader's type, Π_L^* is the equilibrium leader's payoff, and MBR_S is the set of all mixed best responses of the subordinate. Then,

$$D^0_{y=1,m=0} = \{(x_1, x_1)\}, \qquad D_{y=1,m=0} = \emptyset,$$

$$D^0_{y=0,m=0} = \emptyset, \qquad D_{y=0,m=0} = \emptyset,$$

$$D^0_{y=1,m=1} = \{(x_1, x_1)\}, \qquad D_{y=1,m=1} = \emptyset,$$

and $D_{y=0,m=1}$ is a set strictly larger (by inclusion) than $D^0_{y=1,m=0}$ for $p \leq p_i$ if the inequality (4) does not hold. This implies that the subordinate should assign probability one to leader's type $(y=0, m=1)$ if he sees that the leader's project choice differs from the public signal. His effort in this case will reflect his beliefs about the leader type and will be $x_0 = \frac{p(1-q)(1-\alpha)c}{p(1-q)+(1-p)q}$, as stated above.

So, $\left(y=0, m=1, x_1=(1-\alpha)c, x_0=\frac{p(1-q)(1-\alpha)c}{p(1-q)+(1-p)q}\right)$ is an equilibrium surviving D1 refinement for $p_d < p \leq p_i$, and is not such an equilibrium for $p > p_i$.

3. For the leader's strategy of not investing $(y=0)$ and following the private signal $(m=1)$,

the no deviation conditions are

$$\alpha p(a + qx_1 + (1-q)x_0) \geq \alpha(a + x_1) - k \qquad (y = 1, m = 0), \tag{9}$$

$$\alpha p(a + qx_1 + (1-q)x_0) \geq \alpha q(a + x_1) \qquad (y = 0, m = 0), \tag{10}$$

$$\alpha p(a + qx_1 + (1-q)x_0) \geq \alpha\,(a + x_1 \Pr[\,\theta = s_p\,] + x_0 \Pr[\,\theta \neq s_p\,]) - k \qquad (y = 1, m = 1). \tag{11}$$

Inequality (11) is redundant given (9) since $x_1 > x_0$. Also, the right hand side of (10) is less that the right hand side of (9) because of Assumption (A2) since $x_1 > q$. So, it is condition (9) that determines the range of p where the considered strategy is an equilibrium. The condition can be translated into a cubic inequality on $p \in [\frac{1}{2}, 1]$; the respective polynom has a single root on $[\frac{1}{2}, 1]$, and the solution of the inequality is $p \in [p_{ni}, 1]$ for some $p_{ni} \in [\frac{1}{2}, 1]$.

To compare p_{ni} and p_i, note that inequality (8) can be rewritten as

$$p \leq \frac{a + x_1^i - \frac{k}{\alpha}}{a + qx_1^i + (1-q)x_0}$$

and inequality (9) as

$$p \geq \frac{a + x_1 - \frac{k}{\alpha}}{a + qx_1 + (1-q)x_0},$$

where $x_1^i = (1-\alpha)c$ is the equilibrium effort at the equilibrium where the leader invests, and (x_1, x_0) are the efforts in the equilibrium $(y = 0, m = 1)$. Function $\frac{a+x-\frac{k}{\alpha}}{a+qx+(1-q)x_0}$ is monotonically increasing in x, so, since $x_1 < x_1^i$, $p_{ni} < p_i$.

Inequality $p_{ni} > q$ follows from Assumption (A2) and inequality $x_1 > x_0 > q$.

4. The existence of a a mixed-strategy equilibrium "between" the second and the third equilibria for $p_{ni} < p < p_i$ can be established by routine computations.

Now, consider all pure strategies of the leader. Denote by A the project indicated by the public signal, and by B the other one. The following table summarizes the strategies and the

expected payoffs of the leader:

#	y	$\hat{\theta}(s_L = A)$	$\hat{\theta}(s_L = B)$	Π_L/α
1	1	A	A	$a + x_1 - \kappa$
2	1	A	B	$a + (pq + (1-p)(1-q))x_1 + (p(1-q) + (1-p)q)x_0$
3	1	B	B	$a + x_0 - \kappa$
4	1	B	A	$a + (p(1-q) + (1-p)q)x_1 + (pq + (1-p)(1-q))x_0$
5	0	A	A	$q(a + x_1)$
6	0	A	B	$p(a + qx_1 + (1-q)x_0)$
7	0	B	B	$(1-q)(a + x_0)$
8	0	B	A	$(1-p)(a + (1-q)x_1 + qx_0)$

where $\kappa = k/\alpha$.

If $x_1 \geq x_0$, then Strategies 7 and 8 are clearly dominated. Taking note that the subordinate's best response $x_1 \geq q(1-\alpha)c$ and using Assumption (A2), Strategy 5 is dominated by 1. The remaining undominated pure strategies are the ones where the leader invests (Cases 1–2), and Strategy 6 (Case 3).

If $x_1 < x_0$ and $p > q$, all strategies except 3, 6, 7 can be immediately excluded. After that, $x_0 \geq (1-q)(1-\alpha)c$, and Strategy 7 is dominated by 3. If $x_1 < x_0$, $p \leq q$, and if $x_0 \geq q(1-q)(1-\alpha)c/p$, Strategy 8 is dominated by 1. Otherwise, Strategy 8 is dominated by 5 since $x_1 \geq \frac{(1-p)(1-q)(1-\alpha)c}{pq+(1-p)(1-q)}$. Then, $x_1 \geq q(1-\alpha)c$, $x_0 \geq (1-q)(1-\alpha)c$, and all strategies except 3 and 6 are dominated. The analysis of Cases 1 and 2 indicates that $x_1 < x_0$ cannot occur in an equilibrium. □

Proposition 6

Proof. The non-trivial part of the proposition is the claim that the leader's decision to invest and subordinate's effort $x = (1-\alpha)c$ cease to form an equilibrium surviving D1 refinement for $p > p_i$.

Suppose the leader deviated at stage one, and did not invest.

1. Consider subordinate's strategy to choose the project indicated by the public signal. If the private signal of the leader matches the public one, she lets the decision stay. If her private signal differs, she would want the subordinate to choose the project opposite to the public signal. At stage four, she can give the subordinate a small positive sum of money and suggest the project. This deviation may be profitable only for $(y = 0, s_L \neq s_p)$ type of the leader, and brings profit strictly less than the equilibrium one for all other types. D1 (or weaker Intuitive Criterion) requires that the subordinate should trust the leader and choose the project contrary to the public signal. Certainly, in this case the

subordinate re-evaluates the probability of success and chooses his effort level accordingly.

This way, the leader can replicate the decision rule to follow private signal, as well as subordinate's effort and the payoffs of the deviation from Case 2 of Proposition 2. The leader's deviation is profitable from the *ex ante* point of view if $p > p_i$, i.e., when inequality (8) is violated.

2. Suppose that the subordinate chooses a project opposite to what the public signal suggests. The leader in this case may want to renegotiate if her private signal and the public one point to the same project, but the subordinate is choosing the other one. The equilibrium will survive renegotiations if

$$\alpha \max\{(1-p)(1-q)(a+x'), pq(a+x'')\} + p(1-q)x' \leq \alpha(a+x') - k,$$

where $x' = (1-\alpha)c$, $x'' = \frac{pq(1-\alpha)c}{pq+(1-p)(1-q)}$. This condition is stronger than (8), so these strategies form an equilibrium in a subset of $1/2 \leq p \leq p_i$.

□

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