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The Principal Instructs Input or the Agent Sets Input Targets: Which is Preferable in Organizational Control?

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Abstract

This study compares the effectiveness of top-down instructions and decentralization when setting targets in operational efforts. Additionally, this study explores both the content and timing of an agent's decentralized target setting.

The study shows that a top-down target-setting regime is more desirable for the principal than non-instructions because compensation is based on risky output performance and also on riskless input psychological costs. Additionally, even if the principal can select the optimal organizational control by making the agent set a target before or after concluding a contract, either a top-down regime or a decentralized target-setting regime is desirable for the principal.

This study explains the rationality and flexibility of organizational control in actual practice. It also reflects a cross-cultural psychological tendency and explains the agency's relationship with multinational corporations.

Keywords: Organizational control, decentralization, target setting, performance evaluation, contract theory

JEL codes: M21, M41, M52

1. Introduction

This study compares the effectiveness of top-down instructions and decentralization from setting an input target. In this study, the input target is a prior agreement on the level of effort exerted by the subordinate (agent). Within organizations, supervisors (principals) sometimes give instructions for operational efforts to agents and occasionally encourage agents to select levels of effort. Principals cannot observe actual operational efforts, therefore, such practices seem irrational from the perspective of traditional agency theory. I examine whether top-down target setting is useful in controlling the agent initially. If top-down target setting is useful, it could be considered an appropriate benchmark to compare with the target setting decentralization. Additionally, I explore both the content and the timing of the agent's target setting, where the agent can set a target either before or after concluding a contract. This facilitates the consideration of various alternatives for more precise organizational control.

Organizations function better when the agent is evaluated based on verifiable results.[1] This is because the input effort is usually difficult for the principal to observe. However, in practice, a principal in the organization often offers input instructions to an agent or allows the agent to set an input target to control the organization.

For example, to improve profitability, firms prioritize sales districts, seasons, or customers. Therefore, directors often instruct managers to maintain a priority policy. From a cost management perspective, manufacturing department heads might suggest that middle managers comply with a working procedure to reduce spoilage in their respective departments. Moreover, to save the contingent loss, directors may instruct managers to assume a risk-averse policy. These instructions are not aimed at output (performance) but input (effort). Principals give such instructions to agents because they believe they can control the agent's behavior through these instructions. However, principals ordinarily cannot observe the agent's efforts and cannot confirm whether agents comply with their instructions. Therefore, if such instructions are effective, I speculate that the agent tends to follow the instructions offered by the principal.

Similarly, it is also conceivable that principals make agents select input targets. For example, agents sometimes formulate survey plans or production guidelines. This study refers to this process as the "decentralization of target selection."

Traditionally, when determining top-down or participatory decision-making, such as in Baiman and Evans (1983), the main point of concern is environmental information asymmetry between the CEO and managers. In such cases, firms need a system that conveys local information to the top quarter that has decision rights. However, some information is difficult to convey such as the preferences of certain specific customers, expertise knowledge, or a technique. If such information is plentiful, conveying the information rather than delegating decision rights to the agent is more rational (Jensen and Meckling, 1995).

Moreover, participatory decision making enhances the motivation of lower level

[1] For example, Lambert (2001) surveyed plenty of literature precisely.

managers (Zimmerman, 2016). However, if the agent is rational, that agent will likely select the target that maximizes their own expected utility. Given the agent's self-interest, their selection may not necessarily maximize the principal's utility. Then, considering the tradeoff between enhancing the motivation and opportunistic target selection, would it be useful for the principal to decentralize target selection? For decentralization, the principal must control the agent's target selection, therefore, I compare cases of decentralized target selection and top-down instruction.

Comparing the effectiveness of top-down instruction and the decentralization of setting an input target is theoretically and practically important. To analyze these problems, I focus on an agent's psychological tendency. I assume that the agent tends to follow the input target. If the agent does not have such a tendency, instructions will not affect the agent's behavior as the principal cannot observe the agent's behavior. Similarly, the deviation of agents from their instructions is difficult to ascertain, which makes it impossible to punish culpable agents. Therefore, in practice, instructions are meaningless if the agents do not have a tendency to follow those instructions. Moreover, for decentralization, some believe that the motivation to achieve targets will be enhanced. Similarly, if the agent tends to surmise the principal's aim, the principal can control the agent's target selection.

However, no research has directly measured or proved the existence of such a tendency. Only a few studies have analyzed the effects of instructions intended to control an agent's behavior.[2] Therefore, I assume that the agent tends to follow the principal's instructions.

The deviation between (a) the principal's instructions or the selected target and the agent's level of effort and (b) the agent's target selection and the principal's opinion affects the agent's utility. Research from the field of psychology indicates that individuals feel guilty when the outcomes they select are contrary to the expectations of others (Baumeister et al., 1994). A principal's instructions (or expression of opinion) to the agent can be viewed as an explicit indication of their expectations. Some psychology studies have empirically shown that a person who feels guilty as a result of

[2] A consideration of implied contracts can also provide insights into "instructions." Baker et al. (1994) explored the significance of both express contracts (on the basis of verifiable standards) and implied contracts (on the basis of unverifiable standards). Considering the possibility that deviations between instructions and actual input can be measured as an unverifiable subjective performance standard, this study concerns itself with implied contracts. However, because subjective performance standards are not necessarily related to manager instructions, implied contracts can be independently discussed.

failing to meet expectations is likely to become despondent. For example, Tangney (1995) found that shame, guilt, and embarrassment have different qualities, but all of them cause psychological damage, and people seek to avoid these feelings.

Why does an individual experience psychological stress? One probable answer is that some people fear that if they do not achieve something, it could exacerbate an existing problematic situation. In addition, research from the fields of psychology and economics on the topic of identity support this assertion. According to Akerlof and Kranton (2000), identity is the individual awareness of oneself. This definition dictates that identity reflects differences over a broad range of social categories including gender, religion, ethnicity, occupation, and the company for which an individual works. Akerlof and Kranton (2000) further hypothesized that through an awareness of belonging to these categories, differences emerge in the manner in which people believe they should behave. Conversely, people can feel pain when they behave in a manner that violates their expectations of themselves. If a person has a strong awareness of being part of an organization, that person may experience psychological stress when disobeying instructions from a principal of that organization.

For example, Boivie et al. (2011) used an interview and a questionnaire survey to quantify the extent to which CEOs identified with their respective organizations. After controlling for other factors, they found that organizational identification is negatively related to a CEO’s personal use of company equipment. Personal use of company equipment serves as a proxy for agency cost and can be interpreted as a negative relationship between organizational identity and agency cost.

Moreover, through a review of empirical research in psychology, Baumeister et al. (1994) concluded that guilt is derived from relationships with other parties. The authors claimed that empathy and attachment toward another party or exclusion anxiety could affect guilt. Therefore, it follows that agent behavior that deviates from a principal’s instructions can induce stress.

Similarly, a deviation between the agent’s effort to meet the target and actual effort may also induce stress. In a decentralized regime, because the agent explicitly states their targets, failure to achieve the needed level of effort (representing a breach of trust) can result in stress.

An agent can also experience stress when selecting targets because an agent’s selection of targets that differs from those preferred by the principal obviously fails to achieve maximum utility for the principal. Therefore, an agent may set targets that are similar to those emphasized in the principal’s opinion. If the principal commits to expressing an opinion in advance, the agent predicts the opinion that the principal may express. The expectations of the principal and the agent are likely to be consistent. Therefore, in this study, I presume that an agent experiences stress when that agent sets a target that deviates from the principal's expressed opinion.

Even when experiencing stress, for an agent to engage in behavior that deviates from expectations may be rational. For example, Kaplow and Shavell (1994) demonstrated that people sometimes confess their own "illegal" behavior even if they may be subject to punishment. Intuitively, this seems irrational, but it is rational because to keep silent is more costly. In terms of accounting control, agents select actions that depend on the benefits that they may derive from performance evaluations and the costs entailed in performing the task and deviating from the targets.

Moreover, the propensity to experience stress differs according to the individual. Harder et al. (1992) provided support for this notion showing that an individual's attributes and guilt-induced stress levels are correlated. Tangney (1990) developed an indicator to measure feelings of guilt and showed that differences in an individual's stress levels are related to their cognitive processes.

Certain studies have also analyzed the notion of varying identities. For example, Boivie et al. (2011) showed that the degree to which a CEO identifies with their organization is influenced by whether the CEO is invested in the company or has a long-term employment contract. Consequently, the levels of psychological attributes can differ; these factors cause stress, and the resulting stress affects the agent's behavior.

Based on these studies, this study assumes psychological attributes and incorporates two attributes into a single-task, single-period agency model. First, I assess the extent to which the agent is averse to implementing the level of effort that deviates from the input target. Namely, I assess the agent's "attitude toward implementation." Second, this study analyzes the extent to which the agent is averse to setting an input target that deviates from the opinion of the principal; thus, I analyze the agent's "attitude toward target setting."

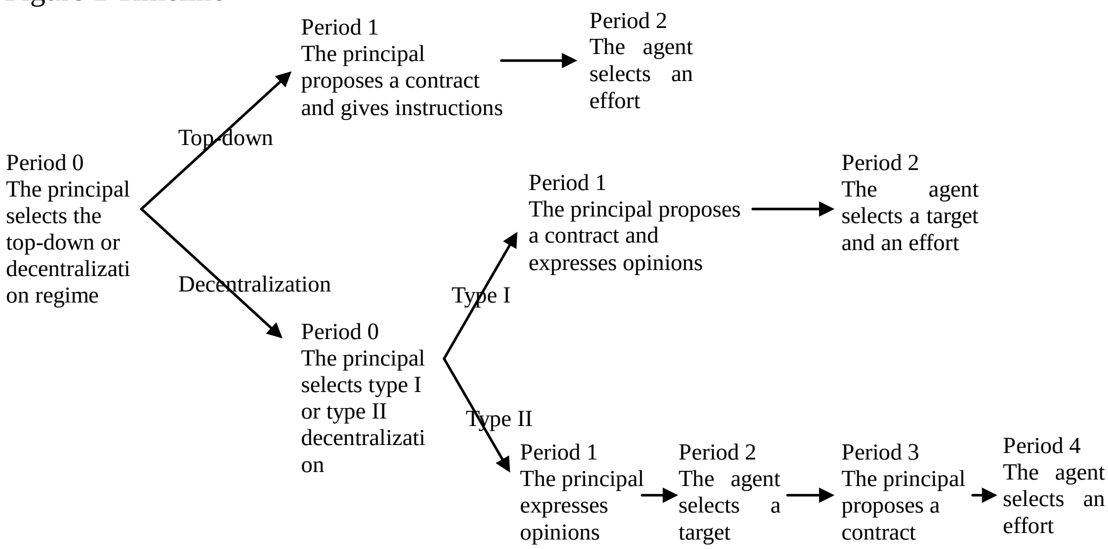
Attitude toward implementation is realized in both top-down and decentralization regimes. In contrast, attitude toward target setting is realized only in the decentralization regime. Therefore, the preference for a top-down or decentralization regime depends on these individual attributes.

2. Model

2.1 Timeline

I begin by explaining the timeline of the model. In period 0, the principal selects the top-down regime or decentralizes the target setting. In a top-down regime, the principal proposes a contract to the agent and issues input targets in period 1. The agent then selects an effort in period 2. In a decentralization regime, the principal has the alternative to make the agent select the target after concluding a contract (type I) or before concluding a contract (type II).

Figure 1 Timeline



The principal selects type I or II in period 0. When the principal selects type I, the principal proposes a contract to the agent and expresses an opinion in period 1. The agent then decides an input target and selects an effort in period 2. I assume that the principal admits the target that is stated by the agent. When the principal selects type II, the principal expresses opinions in period 1. In period 2, the agent states an input target. In period 3, the principal proposes a contract. The agent then selects an effort in period 4. Type II assumes that, for example, the principal may advertise for a project manager or a branch manager. In that case, applicants may present a blueprint for maximizing their performance before concluding the contract. Moreover, the results of a comparison of these decentralized cases with a top-down case are not intuitive. Therefore, I consider a variety of decentralized arrangements in the following sections.

2.2 Basic model

The agent is risk averse and the principal is risk neutral. The agent performs one type of unobservable effort, $e \in \mathbb{R}^+$, which causes psychological and physical fatigue; $k(e) = qe^2$. $q \in \mathbb{R}^+$ is the marginal cost of the effort.

The principal can observe and use verifiable performance data, $\tilde{y} = e + \tilde{\varepsilon}$, $\tilde{\varepsilon} \sim N(0, \sigma^2)$, such as accounting income. $\tilde{y}$ is assumed to be influenced by the measurement error $\tilde{\varepsilon}$. The agent receives the compensation w at the end of the term, and the contract ends. The compensation is shown as an incentive contract $w(\tilde{y})$ proposed by the principal and is assumed to be the linear function $w(\tilde{y}) = \alpha + \beta\tilde{y}$. A fixed salary is shown as α, and β indicates the incentive coefficient.

Additionally, the outcome produced by the agent's effort is given as $\tilde{x}$, and $\mathrm{E}[\tilde{x}] = e$. After the payment of the compensation, the principal gains the residual $\tilde{x} - w(\tilde{y})$, which can be interpreted as, for example, cash flow. Because x is realized after the contract term has ended, it is assumed to be unusable in the incentive contract.

This study assumes an agent utility function U^A as follows:

$$U^A = -\exp\left[-r\left(w(y) - k(e) - R\theta_R(s-e)^2 - (1-R)\left(\lambda\left(s_p - s\right)^2 + \theta_R(s-e)^2\right)\right)\right]. \quad (1)$$

The principal chooses $R = 1$ or 0. $R = 1$ is the top-down regime, and $R = 0$ is the decentralized regime. For simplicity, this paper assumes that when the game starts, the principal has already decided on either a top-down or decentralization regime. r is the absolute risk aversion coefficient.

$s \in \mathbb{R}^+$ is the input target. In a top-down regime, the principal decides s and, in a decentralized regime, the agent decides s. In this study, I assume that the principal or the agent select s to maximize their own utility. $s_p \in \mathbb{R}^+$ denotes an opinion declared by the principal under a decentralized regime.

An agent experiences stress when he or she takes an action that is in conflict with an input. However, the propensity to experience such stress differs from individual to individual. In equation (1), this concept is expressed by $\theta_R \in \mathbb{R}^+$. Thus, θ_R indicates the attitude toward implementation. θ_1 is in the top-down regime, and θ_0 is in the decentralized regime. θ_1 and $\theta_0$are not necessarily the same. $\lambda \in \mathbb{R}^+$ indicates the attitude toward target planning, namely, the attitude of selecting a target as close as possible to s_p as expressed by, or likely to be expressed by, the principal.

Moreover, I assume that the principal, through psychological surveys, can observe λ, θ_1, and θ_0.[3] The compensation, $w(y)$; the cost of effort, $k(e)$; the cost of deviating from an input target in the top-down regime, $\theta_1(s-e)^2$; the cost of deviating

[3] In reality, λ, θ_1, and θ_0 are often unobservable. However, this study focuses on the effects of λ, θ_1, and θ_0. Thus, this study only examines the case in which these variables are observable.

from a target in the decentralization regime, $\theta_0(s-e)^2$, and the cost of deviating from an opinion, $\lambda(s_p - s)^2$; each can be measured in monetary terms and as a multiplicative separable function.

Regardless of whether they are greater than or less than s and s_p, agents are likely to experience stress. Numerous papers, such as Akerlof and Kranton (2005), Bruggen and Moers (2007), Fischer and Huddart (2008), Heinle et al. (2012), and Stevens and Thevaranjan (2010), have modeled this stress using quadratic functions; therefore, using such a model is not unique to this study. However, the model of these prior studies can be applied only to a top-down regime, and a decentralized regime was not discussed. I separate the implementation and planning costs.

The utility function of the principal, U^P, is

$$U^P = x - w(y). \tag{2}$$

The principal is risk neutral and receives what remains after the payment of the compensation.

3. Top-down instructions from the principal

3.1. Equilibrium solution

First, this section considers the case in which the principal selects the top-down regime. The agent selects the most appropriate effort subject to the contract proposed by the principal. This situation is derived as follows.

$$\text{Given } \alpha, \beta \text{ and } s, \quad \max_e \ EU^A = \int -\exp[-r(w(y) - k(e) - \theta_1(s-e)^2)]\, f(y)\, dy. \tag{3}$$

$f(y)$ is the density function. Equation (3) can be modified as

$$EU^A = -\exp[-r(\alpha + \beta e - 0.5r\beta^2\sigma^2 - k(e) - \theta_1(s-e)^2)]. \tag{4}$$

If CE^A is the certainty equivalent because $EU^A = U^A(CE^A)$, then,

$$CE^A = \alpha + \beta e - qe^2 - \theta_1(s-e)^2 - 0.5r\beta^2\sigma^2. \tag{5}$$

The effort exerted to maximize (5) is given as e_{top}.

The principal's expected payoff is $EU^P = e - \mathrm{E}[w(\tilde{y})]$, whereas e_{top} is a condition of the incentive compatibility (IC) constraint. Thus, the problem for the principal is

$$\max_{s,\alpha,\beta} EU^P(e_{top}) = e_{top} - E\left[w(\tilde{y})\middle|e_{top}\right], \tag{6}$$

subject to (7)

$$EU^A(e_{top}) = \int -\exp\left[-r\left(w(y) - k(e_{top}) - \theta_1(s - e_{top})^2\right)\right] f(y)\,dy \geq \underline{U}^A.$$

$\underline{U}^A$ indicates the reservation utility. If the reservation wage is zero, the condition for individual rationality (IR) can be $CE^A = 0$.

Therefore, we obtain Lemma 1.[4]

Lemma 1

In a top-down regime, an agent's effort, e_**; principal instruction,* s_**; proposed incentive contract,* β_**; and the residual are as follows:*

$$e_{top} = \frac{1 + 2r\sigma^2\theta_1}{2q\left(1 + 2r\sigma^2(q + \theta_1)\right)}, \quad s_{top} = \frac{1}{2q}, \quad \beta_{top} = \frac{1}{1 + 2r\sigma^2(q + \theta_1)} \text{ and}$$

$$EU^P_{top} = \frac{1 + 2r\sigma^2\theta_1}{4q\left(1 + 2r\sigma^2(q + \theta_1)\right)}.$$

$e_{top} = s_{top}\,\beta_{top}(1 + 2r\sigma^2\theta_1)$. Therefore, both the level of target and incentive coefficient influence the agent's effort. Further, $e_{top} < s_{top}$, thus, the agent always experiences stress, and the principal compensates for the psychological cost. Lemma 2 shows the effect of θ_1 on the contract.

Lemma 2

(1) The incentive coefficient decreases as θ_1 *increases* $\left(\frac{\partial \beta_{top}}{\partial \theta_1} < 0\right)$.

(2) The expected utility of the principal increases as θ_1 *increases* $\left(\frac{\partial EU^P_{top}}{\partial \theta_1} > 0\right)$.

Lemma 2 (2) shows that top-down instruction is a substitute for the evaluation of output performance for control.

This section examines the effect of not utilizing attitudes toward implementation within incentive contracts. Lemma 1 implies that the principal must compensate for the agent's stress. Accordingly, the case in which the principal instructs the input target may be inefficient. Thus, comparing EU^P_{top} with cases in which the principal does not set input targets and/or use attitude toward implementation within incentive contracts is important.

The utility function of the agent is

[4] The proofs for the lemmas and propositions are shown in the Appendix.

$$U^A = -\exp\left[-r\left(w(y) - k(e)\right)\right]. \tag{10}$$

From this, we obtain equilibriums when the principal does not consider attitudes to implementation within an incentive contract. I refer to EU_*^P and compare EU_*^P with the results of Lemmas 1. Then, we obtain the following proposition.

Proposition 1

(1) $EU_*^P < EU_{top}^P$.

Proposition 1 (1) shows that setting an input target is useful for the principal. When the principal adopts top-down instructions, the compensation is based on risky output performance and riskless input psychological costs. This saves the risk premium. Then, does the result change when we consider a decentralized regime?

Section 4 adds other regimes.

4. Comparison of top-down instructions and decentralization of target selection

4.1 Type I decentralization (setting the target after concluding a contract)

This section addresses the case of decentralized regimes. This section analyzes the type I decentralized case, in which the principal proposes a contract to the agent and issues instructions in period 1, and the agent then states the target and selects an effort in period 2.

Defining the equilibrium solution of the agent's selection of the target and effort along with the principal's expression of the opinion, and proposing the incentive coefficient as s_{dec1} , e_{dec1}, s_{decp1}, and β_{dec1}, respectively, gives Lemma 3.

Lemma 3

The equilibrium solution achieved under decentralized regime I will be

$$s_{dec1} = \frac{1}{2q} - \frac{r\sigma^2\theta_0}{A_1}, \quad e_{dec1} = \frac{\lambda + \theta_0 + 2r\sigma^2\lambda\theta_0}{2qA_1}, \quad s_{decp1} = \frac{1}{2q}, \quad \beta_{dec1} = \frac{\lambda + \theta_0}{A_1}$$

$$EU_{dec1}^P = \frac{\lambda + \theta_0 + 2r\sigma^2\lambda\theta_0}{4qA_1}.$$

Here, $\lambda \in \mathbb{R}^+$ *and* $\theta_0 \in \mathbb{R}^+$. $A_1 \equiv (1 + 2qr\sigma^2)(\lambda + \theta_0) + 2r\sigma^2\lambda\theta_0$

In a decentralized regime, agents do not simply work according to the instructions received but they also select the target. Accordingly, I consider that this equilibrium solution is affected by the agent's attitudes toward implementation and planning. These results are summarized in Lemma 4.

Lemma 4

(1) As λ *increases, the agent sets a higher level for the target effort and, as* θ_0 *increases, the agent sets a lower level for the target effort* $\left(\frac{\partial s_{dec1}}{\partial \lambda} > 0, \frac{\partial s_{dec1}}{\partial \theta_0} < 0\right)$.

(2) As λ *or* θ_0 *increase, the incentive coefficient selected by the principal decreases*

$$\left(\frac{\partial \beta_{dec1}}{\partial \lambda} < 0, \frac{\partial \beta_{dec1}}{\partial \theta_0} < 0\right).$$

(3) As λ *or* θ_0 *increase, the residual obtained by the principal increases*

$$\left(\frac{\partial EU_{dec1}^{P}}{\partial \lambda} > 0, \ \frac{\partial EU_{dec1}^{P}}{\partial \theta_0} > 0\right).$$

Lemma 4 indicates that, in case of type I decentralization, the level of the target, the amount of actual effort, the incentive coefficient, and the principal's utility increase or decrease monotonically against attitudes toward target planning and target implementation. As λ increases, the deviation cost is higher causing the agent to set a target close to the principal's opinion. Therefore, s_{dec1} becomes higher. In contrast, as θ_0 increases, the agent experiences higher stress when that agent cannot achieve the target. Therefore, the agent decreases s_{dec1}, which is set between this trade-off.

Additionally, as λ and θ_0 increase, the incentive coefficient selected by the principal decreases. Therefore, λ and θ_0 are substitutes for the performance evaluation in a type I decentralized regime. Moreover, Lemma 4 (3) indicates that large λ and θ_0 are desirable for the principal.

Then, which is more preferable for the principal, top-down or type I decentralization? Proposition 2 shows the condition.

Proposition 2

(1) If $\theta_1 < \theta_0$ *and* $\lambda_\dagger < \theta_P$, *then* $EU^P_{dec1} > EU^P_{top}$.

$$Here, \qquad \lambda_\dagger \equiv \frac{\theta_0\theta_1}{\theta_0 - \theta_1}.$$

(2) If $\lambda_\dagger > \lambda > 0$ *or* $\theta_1 \geq \theta_0$, *then,* $EU^P_{dec1} < EU^P_{top}$

(3) When the condition of Proposition 2 (1) is satisfied, at least $\theta_1 < \lambda$ *must be true. Additionally, in this condition, we assume that* $\theta_0 \equiv n\theta_1$, $(n > 1)$,

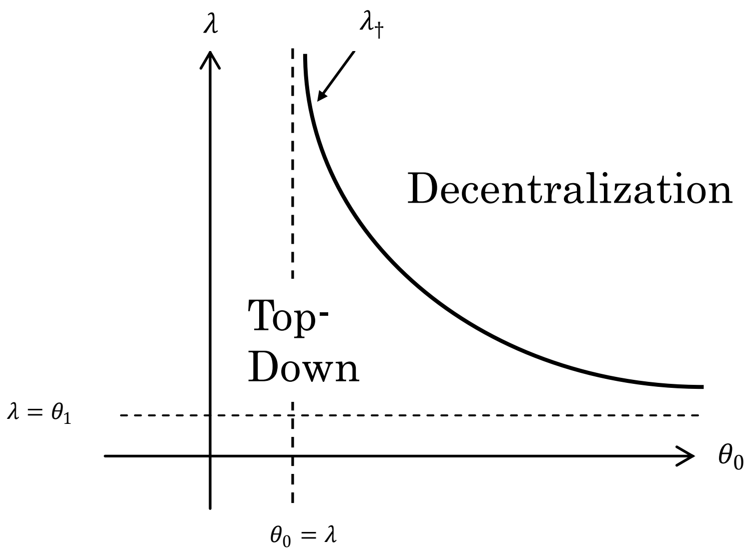
(a) if $n \leq 2$, $\theta_1 < \theta_0 \leq \lambda$ *must be true.*

(b) if $n > 2$, $\theta_1 < \lambda < \theta_0$ *ca be satisfied.*

Proposition 2 (1) shows conditions in which the decentralization regime is superior to the top-down regime. The decentralization regime will be desirable if the agent's attitude toward implementation becomes higher when the principal decentralizes the decision to the right of target setting ($\theta_1 < \theta_0$). Moreover, θ_P must exceed the threshold, $\lambda_\dagger$. According to these conditions, they indicate that when the decentralization regime is superior to the top-down regime, at least $\theta_1 < \lambda$ must be true.

The important point is that the desirability of decentralization can depend on attitude toward both implementation and planning. This indicates that decentralization of target setting can be explained from the viewpoint of individual attributes. There exists the case where we should not decentralize the decision to the right even if the attitude toward implementation is high. Figure 2 shows Proposition 2.

Figure 2 Separation of top-down and decentralization regimes based on proposition 2



When we use questionnaires or interviews based on psychology, we can quantify proxies such as θ_1, $\theta_{0,}$ and λ. Therefore, I assume that the principal can observe θ_1, θ_0, and λ. However, it may be difficult for each firm to measure them accurately. Thus, if we can ignore the accurate value of each individual attribute and focus only on the relative scale for deciding the desirableness of top-down or decentralization regimes, we can apply the results of this study to actual business or empirical research more easily. According to Proposition 2, I show such a guideline based on the relative scale of individual attributes: θ_1, θ_0, and λ.

Table 1 A guideline based on the relative scale of individual attributes

	Scale	Top-down or Decentralizated Regime
(1)	$\theta_1 < \theta_0 < \lambda$	Decentralized (when Proposition 2 (1) is satisfied)
		Top-down (when Proposition 2 (1) is not satisfied)
(2)	$\theta_1 < \lambda < \theta_0$	Decentralized (when Proposition 2 (1) is satisfied)
		Top-down (when Proposition 2 (1) is not satisfied)
(3)	$\lambda < \theta_1 < \theta_0$	Top-down
(4)	$\lambda < \theta_0 < \theta_1$	Top-down
(5)	$\theta_0 < \theta_1 < \lambda$	Top-down
(6)	$\theta_0 < \lambda < \theta_1$	Top-down

In cases (1) and (2), the determination depends on thresholds. In all other cases, a top-down regime is preferable. At least, the principal should not select the decentralization regime when θ_1 is not lower than θ_0 and λ. Where θ_1 is highest, as in (4) and (6), it should be intuitively obvious that a top-down regime is preferable. However, an important contribution of this study is to show instances where it is preferable for a principal to issue input targets. Therefore, for the decentralization demands to succeed, more strict conditions are required than those for the top-down regime. Additionally, we can explain the assignment of the decision from the aspect of asymmetry of information in organizations and the psychological attributes of individuals.

4.2 Type II decentralization (setting the target before concluding a contract)

This section expands the discussion. I assume that the agent set the input target before concluding a contract, and I call this situation type II decentralization. Type II assumes that, for example, the principal may advertise for a project manager or a branch manager. In this case, applicants may present a blueprint for maximizing their performance before concluding the contract.

This section examines decentralized regime II. In this case, the principal issues opinions in period 1. In period 2, the agent states the target. In period 3, the principal proposes a contract. The agent then selects an effort in period 4.

First, the problem for the agent is derived as follows.

given $\alpha, \beta, s_p,$ and s_d,

$$\max_e \; EU^A = \int -\exp\left[-r\left(w(y) - k(e) - \lambda(s_p - s)^2 - \theta_0(s-e)^2\right)\right] f(y)\, dy. \tag{11}$$

The agent's certainty equivalent is

$$CE^A = \alpha + \beta e - qe^2 - \lambda(s_p - s)^2 - \theta_0(s-e)^2 - 0.5r\beta^2\sigma^2. \tag{12}$$

From $\frac{\partial CE^A}{\partial e} = 0$, the optimal effort, e_{dec2} for the agent to choose will be

$$e_{dec2} = \frac{\beta + 2\theta_0 s}{2(q+\theta_0)}. \tag{13}$$

The problem for the principal will be as follows.

$$\text{given } s_p \text{ and } s, \quad \max_\beta EU^P(e_{dec2}) = e_{dec2} - E[w(\tilde{y})|e_{dec2}], \tag{14}$$

subject to $EU^A(e_{dec2})$

$$= \int -\exp\left[-r\left(w(y) - k(e_{dec2}) - \lambda(s_p - s)^2 - \theta_0(s-e)^2\right)\right] f(y)\, dy \geq \underline{U}^A. \tag{15}$$

If the reservation wage is 0, then the IR condition can be $CE^A = 0$. The solution is set as α_{dec2} and β_{dec2}, and the target level of effort offered by the agent can be derived by solving the following.

given $s_p, \max_s \; CE^A(e_{dec2}, \beta_{dec2})$

$$= \alpha_{dec2} + \beta_{dec2}e_{dec2} - qe_{dec2}{}^2 - \lambda\left(s_p - s\right)^2 - \theta_0(s - e_{dec2})^2 - 0.5r\beta_{dec2}{}^2\sigma^2. \tag{16}$$

If this solution is set as s_{dec2}, the opinion expressed by the principal can be derived by solving

$$\max_{s_p} \; EU^P(e_{dec2}, \alpha_{dec2}, \beta_{dec2}, s_{dec2}) = e_{dec2} - E[w(\tilde{y})|e_{dec2}, \alpha_{dec2}, \beta_{dec2}, s_{dec2}]. \tag{17}$$

Setting this solution as s_{decp2} allows us to obtain Lemma 5.

Lemma 5

In decentralized regime II, the agent's target and effort selection and the principal's proposed contract, expressed opinion, and residual will be

$$s_{decp2} = s_{dec2}, \qquad s_{dec2} \in \mathbb{R}^+$$

$$e_{dec2} = \frac{2s_{dec2}\theta_0\big(1 + 2r\sigma^2(q + \theta_0)\big) + 1}{2(q + \theta_0)\big(1 + 2r\sigma^2(q + \theta_0)\big)}, \quad \beta_{dec2} = \frac{1}{1 + 2r(q + \theta_0)\sigma^2}$$

$$EU^P_{dec2} = \frac{1 + 4\theta_0 s_{dec2}(1 - q s_{dec2})\big(1 + 2r\sigma^2(q + \theta_0)\big)}{4(q + \theta_0)\big(1 + 2r\sigma^2(q + \theta_0)\big)}.$$

Here, $\theta_0 \in \mathbb{R}^+$.

Equilibriums of Lemma 5 are not influenced by θ_P. In addition, $s_{dec2} \in \mathbb{R}^+$ because the principal must offer the contract that satisfies the IR and IC conditions even if the agent proposes any target before concluding the contract. Lemma 6 shows the effect of θ_0 on equilibriums.

Lemma 6

(1) (a) When $s_{dec2*} < s_{dec2}$, *as* θ_0 *is increased, the effort is increased* $\left(\frac{\partial e_{dec2}}{\partial \theta_0} > 0\right)$.

(b) When $s_{dec2*} \geq s_{dec2} > 0$, *as* θ_0 *is increased, the effort is decreased* $\left(\frac{\partial e_{dec2}}{\partial \theta_0} < 0\right)$.

(2) As θ_0 *is increased, the incentive coefficient is decreased* $\left(\frac{\partial \beta_{dec2}}{\partial \theta_0} < 0\right)$.

(3) (a) When $\frac{1}{2q} \geq s_{dec2} > s_{dec2\dagger}$, *as* θ_0 *is increased, the expected utility of the principal is increased* $\left(\frac{\partial EU^P_{dec2}}{\partial \theta_0} > 0\right)$.

(b) When $0 < s_{dec2} < s_{dec2\dagger}$ *or* $s_{dec2} > \frac{1}{2q}$, *as* θ_0 *is increased, the expected utility of the principal is decreased* $\left(\frac{\partial EU^P_{dec2}}{\partial \theta_0} < 0\right)$.

$$Here, s_{dec2*} \equiv \frac{1 + 4r\sigma^2(q + \theta_0)}{2q\big(1 + 2r\sigma^2(q + \theta_0)\big)^2}, \qquad s_{dec2\dagger} \equiv \frac{1}{2q\big(1 + 2r\sigma^2(q + \theta_0)\big)}.$$

For the type II decentralization regime, the agent sets the target from any positive real number such that the effect of θ_0 on equilibriums is different depending on s_{dec2}. However, the incentive coefficient is monotonically decreasing by θ_0 indicating that θ_0 is a substitute for a performance evaluation.

When the target is higher than the threshold (s_{dec2*}), as θ_0 is increased, effort is increased. However, a target that is higher by too large an amount ($\frac{1}{2q} < s_{dec2}$) causes over-exertion as θ_0 is increased. Accordingly, the principal's expected utility becomes lower. Therefore, sometimes a case exists in which even if the effort is decreasing, the utility of the principal is increasing or, even if the effort is increasing, the utility of the principal is decreasing.

However, we must be careful that EU_{dec2}^{P} is the expected utility of period 2, which is after the agent proposes s_{dec2} or just before concluding the contract. Therefore, assuming that the distribution of s_{dec2}, which is selected by the agent in period 2, is $f(s)$, the expected value of EU_{dec2}^{P} in period 0, $\mathrm{E}_0[EU_{dec2}^{P}]$, is

$$\mathrm{E}_0[EU_{dec2}^{P}] = \frac{1 + [4\theta_0 \mathrm{E}_0[s] - 4\theta_0 q(\mathrm{E}_0^2[s] + \mathrm{V}_0[s])]\big(1 + 2r\sigma^2(q + \theta_0)\big)}{4(q + \theta_0)\big(1 + 2r\sigma^2(q + \theta_0)\big)} \tag{18}$$

$$\text{Here,} \qquad \mathrm{E}_0[s] = \int_0^{\infty} s f(s) ds$$

In addition, the principal must state that the agent can set any target. If the principal's opinion is different from the agent's target setting, the agent experiences stress. Such stress motivates the agent to close the target to the agent's opinion. However, in the type II regime, the principal satisfies the IR condition after the agent's target setting, which does not work.

Then, Proposition 3 shows the condition in which the type II decentralization regime is superior to the top-down regime.

Proposition 3

(1) The condition in which the type II decentralization regime is superior in period 0 ($E_0[EU^P_{dec2}] > EU^P_{top}$) is

$$\frac{1}{2q} - E_{0\dagger}[s] < E_0[s] < \frac{1}{2q} + E_{0\dagger}[s].$$

Here,

$$E_{0\dagger}[s] \equiv \sqrt{\frac{r^2\sigma^4(q+\theta_0)(\theta_0-\theta_1)}{qA_2A_3\theta_0} - V_0[s]},$$

$$A_2 \equiv 1 + 2r(q+\theta_1)\sigma^2, \qquad A_3 \equiv 1 + 2r(q+\theta_0)\sigma^2.$$

(2) If $0 < V_0[s] < V_{0\dagger}[s]$ *and* $0 < \theta_1 < \theta_0$, $E_{0\dagger}[s] > 0$ *is true.*

Here,

$$V_{0\dagger}[s] \equiv \frac{r^2\sigma^4(q+\theta_0)(\theta_0-\theta_1)}{qA_2A_3\theta_0}.$$

Proposition 3 indicates that the condition is influenced by the agent's attributes and the principal's beliefs (expectation and variance of target, which is set by the agent) about the target. The principal can observe s_{dec2} immediately following the agent's target selection (period 2). However, the principal must make a decision in period 0. In period 0, the principal should decide on a top-down or decentralization regime based on whether $\mathrm{E}_0[EU^P_{dec2}] > EU^P_{top}$. Therefore, Proposition 3 has uncertainty for the principal given the principle of deciding on a top-down or decentralization regime.

Then, I show a numerical example of Proposition 3. Because s_{dec2} must be a positive real number, I assume that $f(s_d)$ is lognormal distribution.

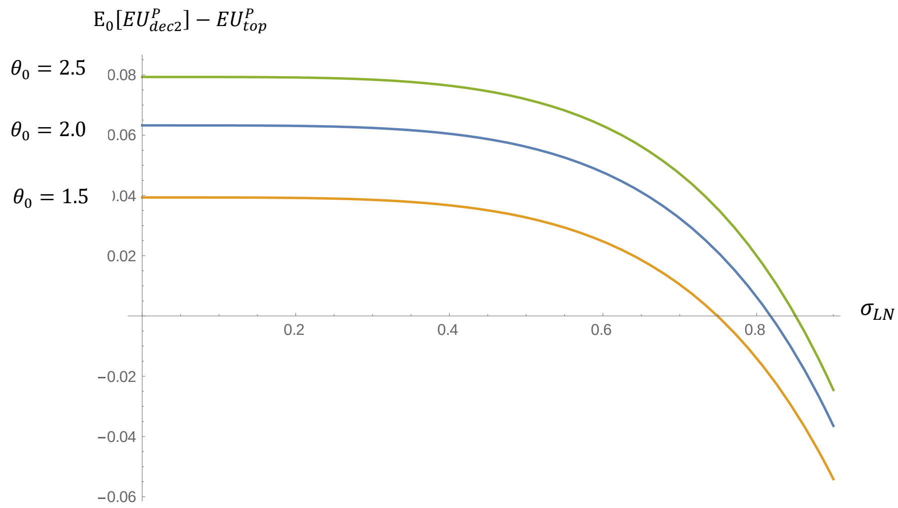
$$f(s) = \frac{1}{s\sigma_{LN}\sqrt{2\pi}}\exp\left[\frac{-(\ln s-\mu)^2}{2\sigma^2_{LN}}\right], \qquad \mathrm{LN}(\mu, \sigma_{LN}). \tag{19}$$

I also assume that $\mu = 0$, $q = 0.5$, $\theta_D = 1$, $r = 0.1$, $\sigma^2 = 10$. When $q = 0.5$ and $\mu = 0$, the ideal target for the principal is $s_{dec2} = 1$, which is the median of the distribution ($\exp[\mu]$). According to these assumptions, I obtain

$$\mathrm{E}_0[EU^P_{dec2}] - EU^P_{top} = \frac{1 - 2\exp[0.5\sigma^2_{LN}](-2+\exp[0.5\sigma^2_{LN}])\theta_0(11+20\theta_0)}{22 + 84\theta_0 + 80\theta_0^2} - \frac{21}{62} \tag{20}$$

Figure 3 shows $\mathrm{E}_0[EU^P_{dec2}] - EU^P_{top}$.

Figure 3 Comparison of $\mathrm{E}_0[EU^P_{dec2}]$ and EU^P_{top}



The threshold depends on θ_0 and is approximated from $\sigma_{LN} = 0.75$ to 0.85. Therefore, when I assume that $f(s)$ is a lognormal distribution, depending on the parameters, a case exists in which the principal can be predicted in period 0, and type II decentralization is certainly superior to a top-down regime. Additionally, if the distribution is more skewed, the probability is lower.

5. Comparison of target-setting timing

In this study, I show that both decentralized regimes can be superior to the top-down regime. Therefore, in this section, I compare all of these equilibriums and examine the decentralized regime that the principal should select.

Proposition 4

(1) The condition in which the type II decentralization is superior to the type I decentralization is

$$\frac{1}{2q} - E_{0\dagger\dagger}[s] < E_0[s] < \frac{1}{2q} + E_{0\dagger\dagger}[s].$$

Here,

$$E_{0\dagger\dagger}[s] \equiv \sqrt{\frac{r^2\sigma^4\theta_0(q+\theta_0)}{qA_1A_3} - V_0[s]},$$

$$A_3 \equiv 1 + 2r(q+\theta_0)\sigma^2, \qquad A_1 \equiv (1+2qr\sigma^2)(\lambda+\theta_0) + 2r\sigma^2\lambda\theta_0.$$

(2) As θ_P is higher, $E_{0\dagger\dagger}[s]$ is lower, but as θ_D is higher, $E_{0\dagger\dagger}[s]$ is higher.

(3) A top-down regime, or type I or II decentralization regimes, can be the optimal organizational architecture for the principal.

First, Proposition 4 (1) is the condition under which type II decentralizations are superior to type I decentralizations. In period 0, it is stochastic. Moreover, Proposition 3 (2) shows that as θ_P is higher, type I is more desirable and, as θ_0 is higher, type II is more desirable. This is consistent with Lemma 6 and that equilibriums of type II are not influenced by θ_P and Proposition 2. However, if both Proposition 4 (1) and Proposition 2 are not simultaneously satisfied, type II will not be alternatives. Proposition 4 (3) shows that both Proposition 4 (1) and Proposition 2 can be satisfied. Thus, the top-down or types I or II decentralization regimes can be the optimal organizational architecture for the principal.

Proposition 4 explains evidence with regard to rationality and flexibility of actual practice. In practice, the principal controls agents based on both input and output performance evaluation. Moreover, there are various types of instructions such as top-down instruction, setting targets by the agent after completing a contract, and setting targets by the agent before completing a contract. This study explains that rationality and flexibility depend on the agent's attributes and the principal's beliefs.

I assume that $q = 0.5,\ r = 1,\ \sigma = 1,\ \lambda = 1,\ \mathrm{V}_0[s] = 0.1$.

Figure 4 Optimal contract for the principal

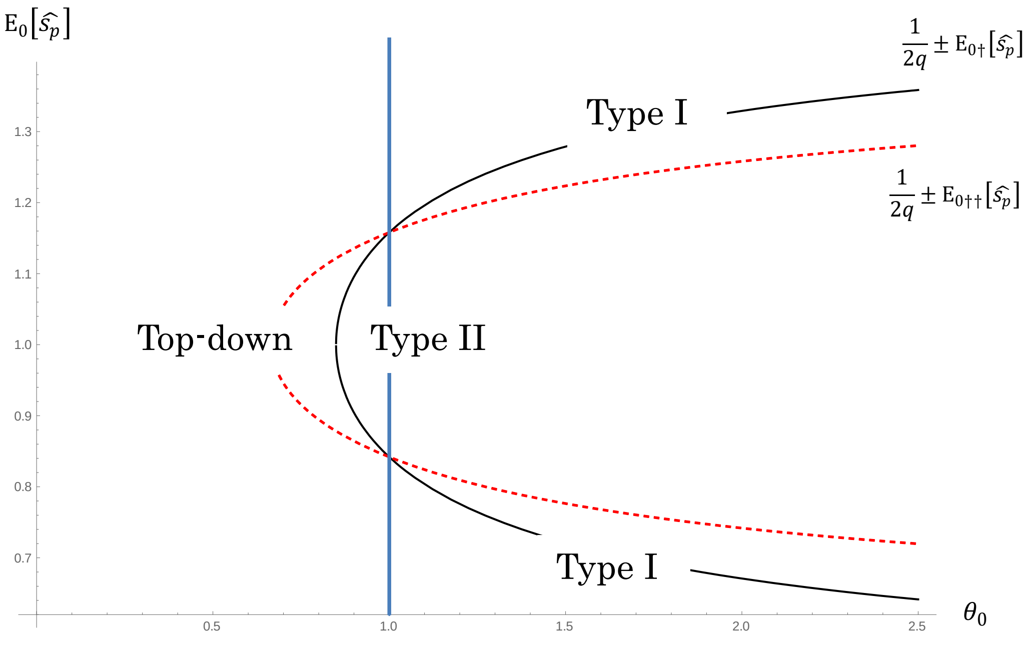


Figure 4 is consistent with Proposition 4 (3). When $\theta_0 < 1$, the top-down regime is superior to the type I decentralization regime. This finding is consistent with Proposition 2. However, when we consider type II decentralization, decentralization can be more desirable. Even if $\theta_0 < 1$, when $\frac{1}{2q} - \mathrm{E}_{0\dagger\dagger}[s] < \mathrm{E}_0[s] < \frac{1}{2q} + \mathrm{E}_{0\dagger\dagger}[s]$ and $\frac{1}{2q} - \mathrm{E}_{0\dagger}[s] < \mathrm{E}_0[s] < \frac{1}{2q} + \mathrm{E}_{0\dagger}[s]$is satisfied, type II decentralization is optimal. That is, the value of considering type II decentralization.

Finally, Corollary 1 shows the sensitivity of the result.

Corollary 1

(1) If $\theta_0 \to 0$ *(i) non-instruction, top-down or type I or II can be the optimal alternatives, and (ii) non-instruction and every types of decentralization are indifferent.*

$$\lim_{\theta_0 \to 0} EU_{dec1}^P = \lim_{\theta_0 \to 0} EU_{dec2}^P = EU_*^P.$$

(2) If $\lambda \to 0$, *(i) non-instruction, top-down, or type I, II can be the optimal alternative, and (ii) non-instruction and type I are indifferent.*

$$\lim_{\lambda \to 0} EU_{dec1}^P = EU_*^P$$

If $\theta_0 \to 0$, the agent sets the same target as the principal's opinion to minimize the planning cost. However, the principal will not care about the target at all. This is the same as non-instruction. In this sense, the principal does not necessarily adopt decentralization. However, if the instruction cost is too large, decentralization can be superior to the top-down. In this case, the principal cannot gain additional benefit from decentralization.

If $\lambda \to 0$, the agent does not experience any stress in deviating from the principal's opinion. Therefore, when the agent sets a target after concluding a contract (type I), the agent sets $s = e$ to minimize the implementation cost. This is the same story as $\theta_0 \to 0$. However, when the agent sets a target before concluding the contract, λ is not influenced to equilibriums. Therefore, Proposition 3 remains, and the principal can gain additional benefits from decentralization.

6. Conclusion

This study focuses on an agent's two individual attributes—attitude toward implementation and attitude toward target setting—and shows the condition where a target-level operational effort by the agent (decentralization of target setting) is more desirable for the principal than when the agent is instructed by the principal (top-down target setting). In addition, I (a) analyzed whether top-down instructions are suitable for controlling the agent, (b) demonstrated the conditions under which the principal should decentralize, and (c) explored both the content and the timing of the principals' opinions.

First, setting the input target can be valuable (Proposition 1). Second, this study shows that either a top-down regime or a type I decentralized target-setting regime is desirable for the principal depending on the agent's individual attributes (Proposition 2). However, for the decentralization demands to succeed, more strict conditions are required than those for the top-down target setting. Moreover, either a top-down regime or a type II decentralized target-setting regime is desirable for the principal (Proposition 3). The condition is influenced by the agent's attributes and the principal's beliefs (expectation and variance of target, which is set by the agent) about the target (Proposition 3).

For decentralized target setting, if the agent sets the target after concluding the contract, attitude toward target setting and attitude toward implementation can substitute performance evaluation control (Lemma 4). In contrast, if the agent sets the target before concluding the contract, only attitude toward implementation works as a substitute for performance evaluation (Lemma 6). Broadly, decentralizing target setting is also valuable for control (Lemmas 4 and 6). We infer that apart from verifiable performance evaluation, input target setting and input instructions work toward organizational control.

Third, I compare all equilibriums and examine the decentralized regime that the principal should select. Then, the top-down regime or type I or II decentralization regimes can be the optimal organizational architecture for the principal (Proposition 4). Moreover, when we consider type II decentralization, decentralization can be more desirable than the result of Proposition 2. That is, the value of considering type II decentralization.

These results can explain a new mechanism for an organizational control system, particularly for performance evaluation or the decentralization of decision rights. I explain the evidence for rationality and flexibility of actual practice. In practice, the principal controls the agent based on both input and output performance evaluation. Moreover, there are various types of instructions such as top-down instruction, agent target after completing a contract, and agent target setting before completing a contract. This study explains that their rationality and flexibility depend on the agent's attributes and the principal's beliefs.

Conversely, one limitation of this study is that the assumptions pertaining to the mathematical model are somewhat ad hoc. Whether individual attributes such as attitude toward instructions and attitude toward target setting exist is unclear. However, considering the roles of such psychological factors in human behavior provides new insights into managerial control and planning research. Thus, the results of this study provide implications for future experimental or practical survey-based research.

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Appendix

Proof of Lemma 1

$$\frac{\partial CE^A}{\partial e} = \beta - 2qe + 2\theta_1(s-e) = 0.$$

Thus,

$$e_{top} = \frac{\beta + 2\theta_1 s}{2(q+\theta)}.$$

The expected compensation is

$$\alpha + \beta e_{top} = q{e_{top}}^2 + \theta_1\left(s - e_{top}\right)^2 + 0.5r\beta^2\sigma^2.$$

Therefore, the principal problem is

$$\max_{s,\alpha,\beta} EU^P\left(e_{top}\right) = \frac{-q\theta_1 s^2 + \theta_1 s + 0.5\beta - 0.25\left(1 + 2r\sigma^2(q+\theta_1)\right)\beta^2}{q+\theta_1}$$

To obtain the target effort, $s_{top,}$ to maximize the previous formula,

$$\frac{\partial EU^P\left(e_{top}\right)}{\partial s} = \frac{\theta_1 - 2sq\theta_1}{q+\theta_1} = 0$$

can be rearranged to become

$$s_{top} = \frac{1}{2q}$$

Then, to obtain the incentive coefficient, β_{top}, rearranging

$$\frac{\partial EU^P\left(e_{top}\,, s_{top}\right)}{\partial \beta} = \frac{0.5 - [0.5 + r(q+\theta_1)\sigma^2]\beta}{q+\theta_1} = 0$$

gives me

$$\beta_{top} = \frac{1}{1 + 2r(q+\theta_1)\sigma^2}.$$

Then, $\left.\frac{\partial EU^P(s,\beta|e_{top})}{\partial s}\right|_{(s,\beta)=(s_{top},\beta_{top})} = \left.\frac{\partial EU^P(s,\beta|e_{top})}{\partial \beta}\right|_{(s,\beta)=(s_{top},\beta_{top})} = 0$ is satisfied.

Thus, I examine the 1 × 1 and 2 × 2 principal submatrixes of the Hessian matrix.

$$\left.\frac{\partial^2 EU^P}{\partial s^2}\right|_{(s,\beta)=(s_{top},\beta_{top})} = -\frac{2q\theta_1}{q+\theta_1} < 0$$

$$\left|\begin{matrix}\frac{\partial^2 EU^P}{\partial s^2} & \frac{\partial^2 EU^P}{\partial s\partial\beta}\\ \frac{\partial^2 EU^P}{\partial\beta\partial s} & \frac{\partial^2 EU^P}{\partial\beta^2}\end{matrix}\right|_{(s,\beta)=(s_{top},\beta_{top})} = \left|\begin{matrix}-\frac{2q\theta_1}{q+\theta_1} & 0\\ 0 & -\frac{1+2r(q+\theta_1)\sigma^2}{2(q+\theta_1)}\end{matrix}\right| > 0$$

Therefore, $(s_{top},\ \beta_{top}) = \left(\frac{1}{2q},\ \frac{1}{1+2r\sigma^2(q+\theta_1)}\right)$ takes the maximal. In addition,

$$\alpha = -\beta_{top}e_{top} + qe_{top}^2 + \theta_1(s_{top} - e_{top})^2 + 0.5r\beta_{top}^2\sigma^2.$$

(QED)

Proof of Lemma 2

(1)

$$\frac{\partial s_{top}}{\partial\theta_1} = 0.$$

(2)

$$\frac{\partial\beta_{top}}{\partial\theta_1} = -\frac{2r\sigma^2}{\left(1+2r\sigma^2(q+\theta_1)\right)^2} < 0.$$

(3)

$$\frac{\partial EU_{top}^P}{\partial\theta_1} = \frac{r^2\sigma^4}{(1+2r\sigma^2(q+\theta_1))^2} > 0.$$

(QED)

Proof of Proposition 1

First, I obtain EU_*^P. The optimal effort is $e_* = \frac{\beta}{2q}$. Then, because e_* is the IC condition. When the reservation wage is set to zero, because the IR condition can be$CE^A = 0$, Therefore, we need to solve

$$\max_{\beta} EU^P(e_*) = \frac{\beta}{2q} - q\left(\frac{\beta}{2q}\right)^2 - 0.5r\beta^2\sigma^2.$$

We obtain $\beta_* = \frac{1}{2q(1+2qr\sigma^2)}$. Substituting each equilibrium solution obtained$EU_*^P = \frac{1}{4q(1+2qr\sigma^2)}$.

Then,

$$EU^P_{top} - EU^P_* = \frac{r^2\sigma^4\theta_1}{\big(1+2r\sigma^2(q+\theta_1)\big)(1+2qr\sigma^2)} > 0.$$

(QED)

Proof of Lemma 3

First, the agent needs to solve the following problem.

given β and s_p, $\max_{e,s} EU^A$

$$= \int -\exp\left[-r\big(w(y) - k(e) - \lambda(s_p - s)^2 - \theta_0(s-e)^2\big)\right] f(y)\, dy.$$

The certainty equivalent of the agent becomes

$$CE^A = \alpha + \beta e - qe^2 - \lambda\big(s_p - s\big)^2 - \theta_0(s-e)^2 - 0.5r\beta^2\sigma^2.$$

From $\frac{\partial CE^A}{\partial e} = 0$, the optimal effort, e_{dec1}, is

$$e_{dec1} = \frac{\beta + 2\theta_0 s}{2(q+\theta_0)}.$$

Additionally, solving $\frac{\partial CE^A(e_{dec1})}{\partial s} = 0$, the solution, s_{dec1} will become

$$s_{dec1} = \frac{\beta\theta_0 + 2s_p(q+\theta_0)\lambda}{2q\lambda + 2\theta_0(q+\lambda)}.$$

e_{dec1}, s_{dec1} satisfy $\left.\frac{\partial CE^A}{\partial e}\right|_{(e,s)=(e_{dec1},s_{dec1})} = \left.\frac{\partial CE^A}{\partial s_d}\right|_{(e,s)=(e_{dec1},s_{dec1})} = 0$. To confirm that these are the maximal, I examine the 1 × 1 and 2 × 2 principal submatrixes of the Hessian matrix.

$$\left.\frac{\partial^2 CE^A}{\partial e^2}\right|_{(e,s)=(e_{dec1},s_{dec1})} = -2q - 2\theta_0 < 0,$$

$$\left.\begin{vmatrix} \frac{\partial^2 CE^A}{\partial e^2} & \frac{\partial^2 CE^A}{\partial e \partial s_d} \\ \frac{\partial^2 CE^A}{\partial s_d \partial e} & \frac{\partial^2 CE^A}{\partial s_d^2} \end{vmatrix}\right|_{(e,s)=(e_{dec1},s_{dec1})} = \begin{vmatrix} -2q - 2\theta_0 & 2\theta_0 \\ 2\theta_0 & -2\theta_0 - 2\theta_P \end{vmatrix}$$

$$= 4(q\theta_0 + q\lambda + \theta_0\lambda) > 0.$$

Therefore, e_{dec1} and s_{dec1} take the maximal.

Then, the principal problem is

$$\max_{\beta, s_p} EU^P(e_{dec1}, s_{dec1}) = e_{dec1} - E[w(\tilde{y})|e_{dec1}, s_{dec1}],$$

subject to $EU^A(e_{dec1}, s_{dec1})$

$$= \int -\exp\left[-r\left(w(y) - k(e_{dec1}, s_{dec1}) - \lambda\left(s_p - s_{dec1}\right)^2 - \theta_0(s_{dec1} - e_{dec1})^2\right)\right] f(y)\, dy \geq \underline{U}^A.$$

If the reservation wage is set to zero, the IR condition can be $CE^A = 0$. Therefore, the IR condition is

$CE^A(e_{dec1}, s_{dec1}) = \alpha + \beta e_{dec1} - k(e_{dec1}, s_{dec1}) - \lambda\left(s_p - s_{dec1}\right)^2 - \theta_0(s_{dec1} - e_{dec1})^2 - 0.5r\beta^2\sigma^2 = 0.$

Substituting this for $EU^P(e_{dec1}, s_{dec1})$ and arranging the first-order condition for β,

$$\beta_{dec1} = \frac{\theta_0 + \lambda}{(1 + 2qr\sigma^2)(\theta_0 + \lambda) + 2r\sigma^2\theta_0\lambda}$$

and, at the same time, arranging the first-order condition for s_p gives us the solution

$$s_{decp1} = \frac{1}{2q}.$$

Thus,

$$\left.\frac{\partial EU^P(e_{dec1}, s_{dec1})}{\partial \beta}\right|_{(\beta, s_p) = (\beta_{dec1}, s_{decp1})} = \left.\frac{\partial EU^P(e_{dec1}, s_{dec1})}{\partial s_p}\right|_{(\beta, s_p) = (\beta_{dec1}, s_{decp1})} = 0.$$

To confirm that these are the maximal, I examine the 1×1 and 2×2 principal submatrixes of the Hessian matrix.

$$\left.\frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial \beta^2}\right|_{(\beta, s_p) = (\beta_{dec1}, s_{decp1})} = -r\sigma^2 - \frac{1}{2(q + \theta_0)} < 0.$$

As $\left.\frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial \beta^2}\right|_{(\beta, s_p) = (\beta_{dec1}, s_{decp1})} < 0,$

$$\left.\frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial s_p^2}\right|_{(\beta, s_p) = (\beta_{dec1}, s_{decp1})} < 0,$$

and $\frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial \beta \partial s_p} = 0,$

$$\left|\begin{matrix} \frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial\beta^2} & \frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial\beta\partial s_p} \\ \frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial s_p\partial\beta} & \frac{\partial^2 EU^P(e_{dec1}, s_{dec1})}{\partial s_p^2} \end{matrix}\right|_{(\beta, s_p)=(\beta_{dec1}, s_{decp1})} > 0.$$

Therefore, β_{dec1} and s_{decp1} take the maximal.

(QED)

Proof of Lemma 4

The results for the partial differential for θ_D and θ_P are shown as follows.

$$\frac{\partial s_{dec1}}{\partial\theta_P} = \frac{r\sigma^2\theta_0(1 + 2qr\sigma^2 + 2r\sigma^2\theta_0)}{A_1^2} > 0, \qquad \frac{\partial s_{dec1}}{\partial\theta_0} = -\frac{r\sigma^2(1 + 2qr\sigma^2)\lambda}{A_1^2} < 0$$

$$\frac{\partial\beta_{dec1}}{\partial\theta_P} = -\frac{2r\sigma^2\theta_0^2}{A_1^2} < 0, \qquad \frac{\partial\beta_{dec1}}{\partial\theta_0} = -\frac{2r\sigma^2\lambda^2}{A_1^2} < 0$$

$$\frac{\partial EU_{dec1}^P}{\partial\theta_P} = \frac{r^2\sigma^4\theta_0^2}{A_1^2} > 0, \qquad \frac{\partial EU_{dec1}^P}{\partial\theta_0} = \frac{r^2\sigma^4\lambda^2}{A_1^2} > 0$$

(QED)

Proof of Proposition 2

$$EU_{top}^P - EU_{dec1}^P = \frac{r^2\sigma^4(\theta_0(\theta_1 - \lambda) + \theta_1\lambda)}{(1 + 2qr\sigma^2 + 2r\theta_1\sigma^2)A_1}$$

becomes the difference between the top-down regime and type I decentralization.

(1) When $\theta_0(\theta_1 - \theta_P) + \theta_1\theta_P < 0$, the decentralized regime dominates the top-down regime.

If all the parameters are positive, the proposition is satisfied when

$$\theta_0 > \theta_1 \text{ and } \theta_P > \frac{\theta_0\theta_1}{\theta_0 - \theta_1}(\equiv \lambda_\dagger).$$

(2) When $\theta_0(\theta_1 - \lambda) + \theta_1\lambda > 0$, the top-down regime dominates the decentralized regime. If all the parameters are positive, the proposition is satisfied when

$$\text{(i) } 0 < \theta_1 < \theta_0 \text{ and } 0 < \theta_P < \frac{\theta_0\theta_1}{\theta_0 - \theta_1}(\equiv \lambda_\dagger),$$

$$\text{or (ii) } \theta_1 \geq \theta_0$$

(3) When $\theta_0 = n\theta_1 \quad (n > 1)$, $\qquad \theta_{P\dagger} = \frac{n\theta_1^2}{(n-1)\theta_1} = \frac{n}{n-1}\theta_1.\ \left(\frac{n}{n-1} > 1\right)$

Therefore, if (1) is true, at the very least, $\theta_P > \theta_1$. Thus, at this time, if $n(n-2) < 0$, it must be that $\lambda > \lambda_\dagger > \theta_0$ because

$$\theta_{P\dagger} > \theta_0 \Leftrightarrow \frac{n}{n-1}\theta_1 > n\theta_1.$$

Therefore, $\lambda > \theta_0$. On the other hand, if $n(n-2) > 0$, it must be that $\lambda_\dagger < \theta_0$, thus, it can be $\lambda < \theta_0$.

(QED)

Proof of Lemma 5

First, I solve the maximization problems of formulae (16) and (17). The IR condition is

$$CE^A(e_{dec2}) = \alpha + \beta e_{dec2} - k(e_{dec2}) - \lambda\left(s_p - s\right)^2 - \theta_0(s - e_{dec2})^2 - 0.5r\beta^2\sigma^2 = 0\,.$$

Therefore, $EU^P(e_{dec2})$ becomes a quadratic concave function of β.

Therefore, from $\frac{\partial EU^P(e_{dec2})}{\partial\beta} = 0$,

$$\beta_{dec2} = \frac{1}{1 + 2r(q+\theta_0)\sigma^2}.$$

Moreover, from

$$\alpha = -\beta_{dec2}e_{dec2} + qe_{dec2}^2 + \lambda\left(s_p - s\right)^2 + \theta_0(s - e_{dec2})^2 + 0.5r\beta_{dec2}^2\sigma^2,$$

I obtain α_{dec2}. Thus, if any s,

$$CE^A(e_{dec2}, \alpha_{dec2}, \beta_{dec2}) = 0.$$

Therefore, s_{dec2} is any positive real number.

Finally, because $EU^P(e_{dec2}, \alpha_{dec2}, \beta_{dec2}, s_{dec2})$ is a quadratic concave function for s_p, rearranging

$$\frac{\partial EU^P(e_{dec2}, \alpha_{dec2}, \beta_{dec2}, s_{dec2})}{\partial s_p} = 0,$$

I obtain

$$s_{decp2} = s_{dec2}.$$

(QED)

Proof of Lemma 6

(1)

$$\frac{\partial e_{dec2}}{\partial\theta_0} = \frac{-1 + 2qs_{dec2}}{2(q+\theta_0)^2} + \frac{2r^2\sigma^4}{(1 + 2qr\sigma^2 + 2r\sigma^2\theta_0)^2}.$$

Therefore, rearranging $\frac{\partial e_{dec2}}{\partial\theta_0} > 0$, I obtain

$$s_{dec2} > \frac{1 + 4qr\sigma^2 + 4r\sigma^2\theta_0}{2q(1 + 2qr\sigma^2 + 2r\sigma^2\theta_0)^2}.$$

(2)

$$\frac{\partial\beta_{dec2}}{\partial\theta_0} = \frac{-2r\theta_0\sigma^2}{(1 + 2r(q + \theta_0)\sigma^2)^2} < 0.$$

(3)

$$\frac{\partial EU^P_{dec2}}{\partial\theta_0} = -\frac{(1 - 2qs_{dec2})^2}{4(q + \theta_0)^2} + \frac{r^2\sigma^4}{(1 + 2qr\sigma^2 + 2r\sigma^2\theta_0)^2}.$$

Therefore, rearranging $\frac{\partial EU^P_{dec2}}{\partial\theta_0} > 0$, I obtain

$$\frac{1}{2q + 4q^2r\sigma^2 + 4qr\sigma^2\theta_0} < s < \frac{1}{2q}.$$

(QED)

Proof of Proposition 3

(1)

$$EU^P_{top} - \mathrm{E}_0[EU^P_{dec2}] = \frac{(1 + 2r\theta_1\sigma^2)(q + \theta_0)(1 + 2qr\sigma^2 + 2r\sigma^2\theta_0)}{4q(1 + 2r(q + \theta_1)\sigma^2)(q + \theta_0)(1 + 2qr\sigma^2 + 2r\sigma^2\theta_0)}$$

$$-\frac{q\left(1 + [4\theta_D\mathrm{E}_0[s] - 4\theta_D q(\mathrm{E}_0^2[s] + \mathrm{V}_0[s])]\big(1 + 2r\sigma^2(q + \theta_0)\big)\right)\big(1 + 2r\sigma^2(q + \theta_1)\big)}{4q(1 + 2r(q + \theta_1)\sigma^2)(q + \theta_0)(1 + 2qr\sigma^2 + 2r\sigma^2\theta_0)}$$

is the difference between top-down and type II decentralization. Therefore, when

$$A_2 \equiv 1 + 2r(q + \theta_1)\sigma^2, \quad A_3 \equiv 1 + 2r(q + \theta_0)\sigma^2,$$

it becomes

$$EU^P_{top} - E_0[EU^P_{dec2}] = \frac{4\theta_0 q\mathrm{E}_0^2[s]A_3 - 4\theta_0\mathrm{E}_0[s]A_3 + 4\theta_0 q\mathrm{V}_0[s]A_3 - 1}{4(q + \theta_0)A_3} + \frac{1 + 2r\sigma^2\theta_1}{4qA_2}.$$

All parameters are positive; it is a quadratic convex function of $\mathrm{E}_0[s]$. Thus, when

$$\frac{1}{2q} - \sqrt{\frac{r^2\sigma^4(q + \theta_0)(\theta_0 - \theta_1)}{qA_2A_3\theta_0} - \mathrm{V}_0[s]} < \mathrm{E}_0[s]$$

$$< \frac{1}{2q} + \sqrt{\frac{r^2\sigma^4(q + \theta_0)(\theta_0 - \theta_1)}{qA_2A_3\theta_0} - \mathrm{V}_0[s]},$$

type II decentralization is superior to top-down instruction.

(2) When

$$\frac{r^2\sigma^4(q+\theta_0)(\theta_0-\theta_1)}{qA_2A_3\theta_0} - \mathrm{V}_0[s] > 0,$$

the condition of Proposition 3 (1) is true, and $E_{0\dagger}[s] > 0$. Therefore, it must be

$$0 < \mathrm{V}_0[s] < \frac{r^2\sigma^4(q+\theta_0)(\theta_0-\theta_1)}{qA_2A_3\theta_0} \text{ and } 0 < \theta_1 < \theta_0.$$

(QED)

Proof of Proposition 4

(1)

$$EU^P_{dec1} - \mathrm{E}_0[EU^P_{dec2}]$$
$$= \frac{\theta_0 + \lambda(1+2r\sigma^2\theta_0)}{4qA_1} - \frac{1 + \left(4\theta_0\mathrm{E}_0[s] - 4\theta_0 q(\mathrm{E}_0^2[s] + \mathrm{V}_0[s])\right)A_3}{4(q+\theta_0)A_3},$$

$$A_3 \equiv 1 + 2r(q+\theta_0)\sigma^2, \qquad A_1 \equiv (1+2qr\sigma^2)(\lambda+\theta_0) + 2r\sigma^2\lambda\theta_0.$$

Therefore, when

$$\frac{1}{2q} - \sqrt{\frac{r^2\sigma^4\theta_0(q+\theta_0)}{qA_1A_3} - \mathrm{V}_0[s]} < E_0[s]$$
$$< \frac{1}{2q} + \sqrt{\frac{r^2\sigma^4\theta_0(q+\theta_0)}{qA_1A_3} - \mathrm{V}_0[s]},$$

$EU^P_{dec1} < \mathrm{E}_0[EU^P_{dec2}]$.

(2)

If $B \equiv \frac{r^2\sigma^4\theta_0(q+\theta_0)}{qA_1A_3} - \mathrm{V}_0[s]$, then

$$\frac{\partial B}{\partial \theta_0} = \frac{(1+2qr\sigma^2)\theta_0^2 + \lambda A_1\left(q(1+2qr\sigma^2) + 2\theta_0(1+qr\sigma^2)\right)}{qA_1^2A_3^2} > 0,$$

$$\frac{\partial B}{\partial \lambda} = -\frac{r^2\sigma^4\theta_0(q+\theta_0)}{q\left((1+2qr\sigma^2)\lambda + \theta_0 + 2r\sigma^2(q+\theta_0)\theta_0\right)^2} < 0\,.$$

(3) If

$$\mathrm{E}_{0\dagger\dagger}[s] \equiv \sqrt{\frac{r^2\sigma^4\theta_0(q+\theta_0)}{qA_1A_3} - V_0[s]},$$

then

$$\frac{1}{2q} + \mathrm{E}_{0\dagger\dagger}[\widehat{s_p}] - \left(\frac{1}{2q} - \mathrm{E}_{0\dagger}[\widehat{s_p}]\right) > 0 \text{ and } \frac{1}{2q} + \mathrm{E}_{0\dagger}[\widehat{s_p}] - \left(\frac{1}{2q} - \mathrm{E}_{0\dagger\dagger}[\widehat{s_p}]\right) > 0.$$

Next,

$$\frac{1}{2q} + \mathrm{E}_{0\dagger}[\widehat{s_p}] - \left(\frac{1}{2q} + \mathrm{E}_{0\dagger\dagger}[\widehat{s_p}]\right) = \sqrt{\frac{r^2\sigma^4(q+\theta_0)(\theta_0-\theta_1)}{qA_2A_3\theta_0} - \mathrm{V}_0[s]} - \sqrt{\frac{r^2\sigma^4\theta_0(q+\theta_0)}{qA_1A_3} - V_0[s]},$$

thus, the condition in which

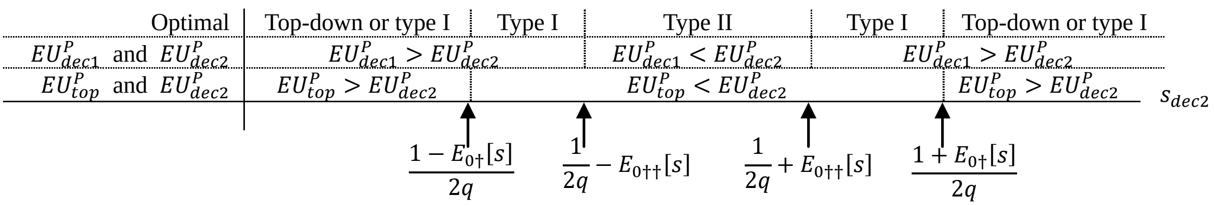
$$\sqrt{\frac{r^2\sigma^4(q+\theta_0)(\theta_0-\theta_1)}{qA_2A_3\theta_0} - \mathrm{V}_0[s]} > \sqrt{\frac{r^2\sigma^4\theta_0(q+\theta_0)}{qA_1A_3} - V_0[s]}$$

is

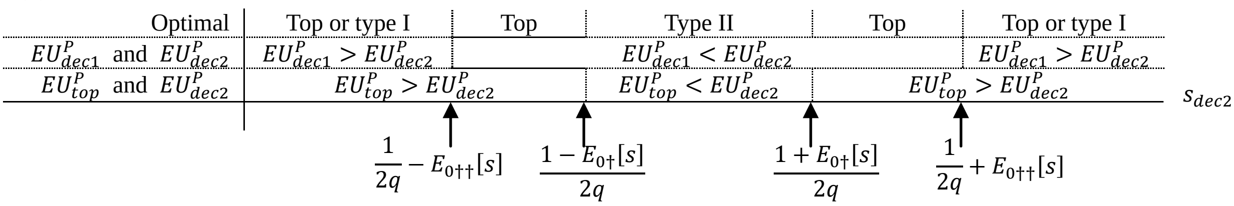
$$0 < \mathrm{V}_0[\widehat{s_p}] < \frac{r^2\sigma^4\theta_0(q+\theta_0)}{A_3q} \text{ and } \theta_1 < \frac{\theta_P\theta_0}{\theta_P+\theta_0}.$$

Therefore, we consider two patterns ((a) and (b)) that depend on s_{dec2} indicating the optimal organizational architecture for the principal.

(a)



(b)



(QED)