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博士論文

Theoretical and Experimental Studies on
Target Setting and the Ratchet Effect

(目標設定とラチェット効果に関する理論研究および実験研究)

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Table of Contents

1. INTRODUCTION.....	1
1.1. Target Setting and the Ratchet Effect.....	1
1.2. Summary of this Dissertation	2
2. RELATED LITERATURE.....	7
2.1. Target Ratcheting and the Ratchet Effect	7
2.2. The Existence of the Ratchet Effect	8
2.3. Mitigating the Ratchet Effect	11
2.4. Inequity Aversion	12
2.5. The Positioning of this Study	13
3. A MODEL ON THE RATCHET EFFECT IN TEAMS WITH LEARNING	15
3.1. Introduction.....	15
3.2. The Setting of the Model	15
3.3. Benchmark Analyses.....	17
3.4. Analyses on the Full-separating Short-term Contract.....	18
3.5. Analyses on the Full-pooling Short-term Contract	26
3.6. Discussion.....	31
3.6.1. Feasibility of Full Separation	31
3.6.2. Comparison of Contracts	32
3.7. Conclusion	33
4. AN EXPERIMENT ON THE RATCHET EFFECT IN TEAMS	34
4.1. Introduction.....	34
4.2. Experimental Design.....	34
4.2.1. The Team-Production Game	34
4.2.2. Treatments.....	36
4.2.3. Participants and Sessions.....	37
4.2.4. Payment Scheme	38
4.3. Equilibrium Predictions and Hypotheses.....	38
4.4. Results.....	41
4.4.1. Definitions of Variables.....	42
4.4.2. Testing the Existence of the Ratchet Effect (H1 & H3)	43
4.4.3. Testing the Impact of Learning on the Ratchet Effect (H2)	44
4.5. Conclusion	45
5. CONCLUSION.....	47
REFERENCES	48

APPENDIX.....	63
A. Equilibriums in Each Treatment.....	63
A.1. <i>ONE</i> with Self-regarding Individuals	63
A.2. <i>NOLEARN</i> with Self-regarding Individuals	63
A.3. <i>LEARN</i> with Self-regarding Individuals.....	64
A.4. <i>ONE</i> with Inequity-averse Individuals	65
A.5. <i>NOLEARN</i> with Inequity-averse Individuals	65
A.6. <i>LEARN</i> with Inequity-averse Individuals	71
B. An Experimental Procedure for Measurement of Inequity Aversion	72
C. Original Experimental Instructions (Japanese)	74
C.1. Instructions of the Team-production Task in <i>ONE</i>	74
C.2. Instructions of the Team-production Task in <i>NOLEARN</i>	78
C.3. Instructions of the Team-production Task in <i>LEARN</i>	85
C.4. Instructions of the Task for Measuring Inequity Aversion	93
D. Translated Experimental Instructions (English)	95
D.1. Instructions of the Team-production Task in <i>ONE</i>	95
D.2. Instructions of the Team-production Task in <i>NOLEARN</i>	99
D.3. Instructions of the Team-production Task in <i>LEARN</i>	107
D.4. Instructions of the Task for Measuring Inequity Aversion	115

List of Figures

Figure 1: The Feasibility of the Full-separation Contract when $p = 0.3$, $\delta = 1$, $\theta_G = 0.1$, $\theta_B = 1$, $\epsilon = 0.01$	51
Figure 2: The Feasibility of the Full-separation Contract when $p = 0.3$, $\delta = 1$, $\theta_G = 0.7$, $\theta_B = 1$, $\epsilon = 0.01$	51
Figure 3: Π_{SEP} and Π_{POOL} when $p = 0.3$, $\delta = 1$, $\theta_G = 0.1$, $\theta_B = 1$, $\epsilon = 0.01$	52
Figure 4: Π_{SEP} and Π_{POOL} when $p = 0.3$, $\delta = 1$, $\theta_G = 0.7$, $\theta_B = 1$, $\epsilon = 0.01$	52
Figure 5: Timeline of a Round in Two-periods Treatments	52
Figure 6: Equilibriums in NOLEARN depending on the Inequity Aversion	53
Figure 7: The Scatter Plot of Participants' Inequity Aversion	54
Figure 8: The Empirical Cumulative Distribution Functions of Skilled Workers' Decisions in the First Period.....	55
Figure 9: The Empirical Cumulative Distribution Functions of Newcomers' Decisions in the First Period.....	55
Figure 10: The Empirical Distribution Functions of Skilled Workers' First Period's Decisions in LEARN Treatment—Comparison of 1–10 Rounds' Data and 11–20 Rounds' Data—	56
Figure 11: Choice Problems for Measuring the Preference Parameter of Envy	72
Figure 12: Choice Problems for Measuring the Preference Parameter of Guilt	73

List of Tables

Table 1: A Payoff Chart for the First period's Decision when a Decision-maker is a Skilled Worker.....	57
Table 2: A Payoff Chart for the First period's Decision when a Decision-maker is a Newcomer	57
Table 3: The Relationship between the First Period's Decisions and the Second Schedule in NOLEARN	58
Table 4: The Relationship between the First Decisions and the Second Schedule in LEARN ..	58
Table 5: A Payoff Chart for the Second period's Decision when a Decision-maker is a Skilled Worker in NOLEARN.....	59
Table 6: A Payoff Chart for the Second period's Decision when a Decision-maker is a Newcomer in NOLEARN.....	59
Table 7: A Payoff Chart for the Second period's Decision when a Decision-maker is a Skilled Worker in LEARN.....	60
Table 8: A Payoff Chart for the Second period's Decision when a Decision-maker is a Newcomer in LEARN.....	60
Table 9: Equilibriums in Each Treatment	61
Table 10: Summary Statistics	61
Table 11: The Results of the Wilcoxon Rank-Sum Tests for Decisions in the First Period.....	62

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1. INTRODUCTION

1.1. Target Setting and the Ratchet Effect

In the literature on management accounting, one of the most widely researched topics is the role of incentive systems, in which targets are an important factor (Merchant and Van der Stede, 2017). From those researches, it has emerged that firms often pay and/or promote their employees depending on their target achievements (e.g., Merchant et al., 2018; Murphy, 2000). Currently, target setting is one of the major research fields in management accounting (Indjejikian et al., 2014b; Matějka, 2018).

By investigating how firms determine and use their targets, the literature on target setting found that they are commonly determined based on past performance (e.g., Dekker et al., 2012; Leone and Rock, 2002; Murphy, 2000). This target-setting method was named target ratcheting (Indjejikian et al., 2014b). Based on survey data on CEOs' compensations in U.S. firms, Murphy (2000) reported that a large percentage of firms use past performance information to determine their CEOs' performance targets.

While this is prevalent, the economic theory suggests that target ratcheting is susceptible to an incentive problem called the ratchet effect (Laffont and Tirole, 1993; Weitzman, 1980). Employees expect that once good performance is recorded, the next period's targets will become more difficult, and thus, they have an incentive to limit their current performance to ensure that future targets are easily attainable. If the ratchet effect prevails, the firm's performance is lower than the level that could be attained if every employee exerted his/her maximum capability. Thus, it is important to overcome this problem, as has been extensively discussed in the literature (Indjejikian et al., 2014b).

Previous studies have empirically investigated whether the ratchet effect occurs in practice as predicted in theory (e.g., Bouwens and Kroos, 2011; Chaudhuri, 1998; Leone and Rock, 2002; Murphy, 2000), in addition to discussing how managers can overcome this problem (e.g., Aranda et al., 2014; Baron and Besanko, 1984; Cardella and Depew, 2018; Charness et al., 2011; Indjejikian et al., 2014a; Indjejikian and Nanda, 2002). However, these studies have focused on exploring this incentive problem in an independent work environment.

In contrast to prior studies, this paper seeks to explore the ratchet effect within a team environment. A team is considered to have formed when multiple agents conduct a

task together, and their behavior interdependently determines their overall output. In addition, the principal cannot observe the output per agent, but instead sees the output per team (Holmstrom, 1982).

The interdependent nature of team work environments, which is absent in independent work environments, may impact the agents' incentives to commit the ratchet effect, as well as the principal's means to mitigate it.

In regards to agents' incentives to commit the ratchet effect, agents work together in interdependent work environments such that each one's behavior impacts their own rewards and their teammates' rewards. Thus, the agents may be more likely to consider their colleagues when deciding whether to commit the ratchet effect. This suggests that other-regarding preferences may play a more significant role in teams than in independent work environments.

In terms of the principal's means to cope with the ratchet effect, the interdependent nature of work environments may provide other opportunities for the ratchet effect to be mitigated.

This study investigates the mechanism of the ratchet effect—the agents' incentive to commit the ratchet effect and the principal's means to cope with this problem—and how it is affected by the interdependent nature of work environments with teams.

1.2. Summary of this Dissertation

This dissertation consists of a theoretical analysis and a laboratory experiment, both of which discuss the ratchet effect in teams.

First, using a two-period adverse-selection model in which a principal manages a team with two agents, the principal's novel means to mitigate the ratchet effect is theoretically investigated. Specifically, this section focuses on the impact of learning among teammates, a phenomenon that could arise in an interdependent environment.

The concept of learning among teammates considered in this study is as follows. I assume that employees will improve their skills as they gain experience, the extent of growth will differ depending on the employees' initial skill levels and their teammates' skill levels. Given the interdependent work environment, employees can improve their skills by learning from their teammates. Berg et al. (1996) demonstrated that workers in production teams often informally teach each other shortcuts, problem-solving, or other ways to improve their work. Additionally, unskilled employees that are paired with skilled employees may grow more because of the knowledge that is imparted to them (Hamilton et al., 2003); it could also be the case that unskilled employees who have more room for improvement spontaneously learn from a good role model.

Assuming the above, the results of the theoretical analysis demonstrate that the more salient such learning is, the more easily the principal can prevent the ratchet effect. The driving force of this result is a characteristic of learning among teammates in which unskilled agents that are paired with skilled agents grow more than others.¹

The logic in which how the above characteristic of learning among teammates helps the principal to cope with the ratchet effect is as follows: To adjust targets according to the agents' skill level, the principal asks the agents to self-report their own skill levels. When there is no learning, since each agent is not asked to report his/her teammate's skill level, each agent's report naturally provides information about his/her own skill. If an agent reports his/her type as unskilled in the first period, then the principal cannot ascertain whether this agent is lying. Thus, in the first and the second periods, the principal assigns a target corresponding to the unskilled agent's skill level, accounting for the possibility that the agent's true skill level is low and he/she give up to work if the principal offers too demanding targets.

The logic in which how the above characteristic of learning among teammates helps the principal to cope with the ratchet effect is as follows: To adjust targets according to agents' specific skill levels, the principal will ask the agents to self-report their own skill levels. When there is no learning, each agent's report simply provides information about his/her own skills. If an agent reports his/herself as being unskilled in the first period, then the principal cannot ascertain whether this agent is lying. Thus, in the first and the second periods, the principal will assign a target corresponding to the unskilled agent's skill level, accounting for the possibility that the agent's true skill level is low, in which case s/he is likely to give up if the principal has demanding targets.

In contrast, in the presence of learning, a correlation between each agent's private information (i.e., skill levels) is introduced in the second period regardless of the initial correlation between the agent's private information. If one agent is skilled, then his/her teammate will have at least a moderate skill level in the second period. When that teammate is also a skilled agent, the above statement is definitely true. In addition, when the teammate is initially an unskilled agent, s/he will significantly improve his/her skill level by learning from the skilled partner; they will, therefore, develop their skills

¹ If every agent grows the same amount regardless of their initial skill levels and that of their teammates, then the ratchet effect may not be deterred by the presence of such learning. In contrast, if the unskilled agents grow more than the skilled agents regardless of their teammates' initial skill levels (i.e., the unskilled agents grow more than the skilled ones not only when they are paired with the skilled agents but also they are paired with the unskilled agents), then such learning may more easily deter the ratchet effect than the learning which I analyzed in the model.

to a moderate or even high level.

Given the above correlation, each agent's report can also provide information on their teammate's type. Since the principal understands how learning introduces the correlation, they can utilize this correlation structure for deterring the ratchet effect.

Specifically, when one agent reports his/her type as unskilled and the other reports his/her type as skilled, then the principal can infer from the latter agent's report that in the second period the former agent's skill level will be no less than the improved skill level of initially unskilled employees who are paired with skilled employees. Then, in the second period, the principal can assign the former agent a target corresponding to the improved skill level of unskilled employees, and this target will be more demanding than that of unskilled employees who have not improved. This means that even if a skilled agent misreports his/her type, in the presence of learning, s/he will be assigned a target in the second period that is more demanding than in the absence of learning, and his/her misreporting benefit will decrease.

Second, using a laboratory experiment of a team-production task performed by undergraduate and graduate students, the theoretical predictions of agents' incentives to commit the ratchet effect in teams are tested, as well as the principal's means to cope with the ratchet effect problem in teams.

Regarding the agent's incentive to commit the ratchet effect, I theoretically predict that the occurrence of the ratchet effect in teams depends on the agents' inequity-aversion. If the agents have a standard preference and do not care about inequity at all, then the ratchet effect will occur. The more inequity-averse the agents are, the less likely the occurrence of the ratchet effect.

Inequity aversion is one of the other-regarding preferences, which represents individuals' preference for disliking inequity among members (Dhami, 2016). In this study, the notion of inequity-aversion is formalized based on Fehr and Schmidt's (1999) model. In their work, Fehr and Schmidt (1999) considered an inequity-averse individual to suffer from *envy* (*guilt*) when s/he gets less (more) compared to his/her counterpart.

The logic of why sufficiently inequity-averse agents lose their incentive to commit the ratchet effect is brought about by one of the following two logical arguments. First, when a skilled agent misreports his/her type as unskilled, s/he will feel guilty based on the enhanced payoff compared to his/her teammates. If this feeling of guilt outweighs the benefit of having easier targets in future, then the agent will spontaneously refrain from committing the ratchet effect.

Second, when a skilled agent misreports his/her type as unskilled and enjoys easy future targets, his/her teammate will envy that agent. If this feeling of envy is

sufficiently strong, then the teammate may penalize the dishonest agent by deciding not to cooperate in the team's production activity in the second period, which drastically reduces the team's performance and impairs the dishonest agent's benefits from the easy targets. It is worth noting that this second logic arises from an interdependent nature and inequity-aversion. On account of their interdependent nature, the agents can influence their teammates' payoffs by changing their behavior to influence the team's output. In addition, agents that are sufficiently inequity-averse (envious) have an incentive to prevent teammates from committing the ratchet effect. Thus, teams with sufficiently inequity-averse agents can govern their behavior through mutual threats, thereby deterring the ratchet effect by themselves.²

In terms of the principal's means to cope with the ratchet effect, theoretical predictions on learning, which are driven by the model analyses explained above, are tested in this research.

The results of the experiment reveal that the ratchet effect occurs in teams. Skilled workers tended to misrepresent their types (i.e., reported being unskilled) more frequently in two periods without learning treatment (*NOLEARN*) than in a one-period treatment (*ONE*), which is free from an incentive to commit the ratchet effect. I measured Fehr and Schmidt (1999) inequity aversion for each participant and confirmed that their inequity-aversion levels were low enough to fall within a range for which the ratchet effect is theoretically expected to occur.

The experimental results also reveal that the ratchet effect is significantly mitigated when learning is salient compared to when it is absent. Skilled workers more frequently represented their true type in two periods with the most salient learning treatment (*LEARN*) than in two periods without learning treatment (*NOLEARN*).

As such, the contributions of this dissertation are as follows; first, this study adds to the literature on target setting and the ratchet effect (e.g., Aranda et al., 2014; Bouwens and Kroos, 2011; Cardella and Depew, 2018; Casas-Arce et al., 2018; Chaudhuri, 1998; Charness et al., 2011; Cooper et al., 1999; Indjejikian and Nanda, 2002; Indjejikian et al., 2014b; Laffont and Tirole, 1993; Leone and Rock, 2002; Matějka, 2018; Weitzman, 1980) by considering agents' incentives to commit the ratchet effect in teams and the principal's means to mitigate it.

This study theoretically explains that, because of the impact of inequity-aversion

² The first logic could also hold in the case of independent work environments with multiple agents. On the other hand, the second logic cannot be observed in independent work environments, because the agents cannot manipulate their colleagues' performance, and they cannot penalize each other.

and interdependent work environments, the employees' incentive to commit the ratchet effect in teams differs from that in independent work environments. This suggests that future research ought to further investigate the impact of different other-regarding preferences in order to deepen our understanding of this incentive.

More specifically, this study shows that the ratchet effect is deterred in teams with strong inequity-averse agents, because the agents mutually govern their behavior. This implies that the ratchet effect is automatically deterred in such teams without any management activity by the principal. This can be a possible explanation for the unanswered question, why is the practice of setting targets based on past performance prevalent?

This study also theoretically and experimentally demonstrates that learning among teammates works as a new tool for the principal to deter the ratchet effect in teams. By introducing the correlation between the agents' skill levels, learning makes each agent's report on his/her own type informative about the other teammates' type. This suggests that managers can cope with the ratchet effect in teams by determining targets considering the correlation structure. The ratchet effect will be mitigated by adjusting target levels not only based on past performance, but also based on the improvements that can arise as a result of learning.

Second, this study reveals the indirect benefit of employees' learning for firms, which is not thoroughly discussed in the existing literature on learning (e.g., Berg et al., 1996; Hamilton et al., 2003). The results reveal that facilitating learning in teams benefits firms by not only inducing skill improvement in unskilled employees, but also by preventing skilled employees from committing the ratchet effect. In terms of human resource management implications, this suggests that we need to account for this indirect role when discussing the role of employees' learning and training. As a practical implication, this also shows that facilitating knowledge sharing among team members, providing mentoring opportunities for low-performing employees, and/or cultivating a cooperative culture may contribute to preventing skilled employees from shirking.

The remainder of this dissertation is organized as follows. Chapter 2 summarizes the related literature. Chapter 3 analyzes a theoretical model for the impact of learning on the ratchet effect in teams. Chapter 4 presents a laboratory experiment on the ratchet effect in teams, and Chapter 5 offers a conclusion. In addition, Appendix A analyzes the equilibrium behaviors for each experimental treatment; Appendix B explains the experimental procedure for measuring inequity-aversion; Appendix C shows the original experimental instructions in Japanese; and Appendix D shows the experimental instructions that are translated into English.

2. RELATED LITERATURE

2.1. Target Ratcheting and the Ratchet Effect

The literature on target setting investigates how firms determine and use their employees' targets, as well as the incentive effect of these targets. They found that targets are commonly determined based on past performance (Dekker et al., 2012; Leone and Rock, 2002; Murphy, 2000). Such a target-setting method is called target ratcheting³ (Indjejikian et al., 2014b).

Although prevalent in practice, target ratcheting is theoretically considered to cause an incentive problem called the ratchet effect (Indjejikian et al., 2014b; Weitzman, 1980). Intuitively speaking, once the good performance is recorded, the next period's targets will be revised into more difficult ones. Employees thus have an incentive to limit their current performance in order to have easier targets in future.

In economic theory, the ratchet effect problem is formalized as a dynamic adverse selection problem in which the principal and the agent contract over multiple periods, while having information asymmetry between the two (Laffont and Tirole, 1993). Before explaining the ratchet effect, I will briefly explain the basic adverse-selection problem.

In the case of adverse selection, there is information asymmetry between the principal and the agent before they sign a contract. Whereas the agent knows his/her own type (i.e., their own ability), the principal only knows the distribution of the agent's type.

Although the principal may want to tailor the contract to the agent's true ability, the presence of information asymmetry means that the principal cannot discern which agent has what ability *ex-ante*, and the principal cannot assign the contract corresponding to the agent's true ability. For example, a principal may wish to assign a higher output requirement to an agent with a higher ability in order to utilize their capability. However, because the principal does not know the agent's ability for sure, the principal cannot directly assign work on that basis.

Therefore, in order to execute a contract that is tailored to the agent's true ability, the principal needs to design the agent's incentive to select the appropriate contract by themselves. In this context, highly capable agents can benefit from an easy task if they

³ As Indjejikian et al. (2014b) argued, that target ratcheting is different from the ratchet effect. Target ratcheting refers to revising targets based on past performance. The ratchet effect refers to an incentive problem caused by target ratcheting.

misreport their ability, since they can conduct the same amount of output requirement with less cost than low-ability agents. To deter this misreporting incentive, the principal needs to provide some informational rent that is no less than the amount of deviation benefit that the agents can attain if they misreport their ability.

If the relationship becomes dynamic, such that the principal and the agent contract over multiple periods, then misreporting can benefit a highly capable agent throughout continuous periods, not just the first period. Since the principal can adjust the contractual offer for the continuation periods considering the first period's results (if the high-ability agent reveals his/her true ability in the first period), then the principal will assign a demanding offer in the continuation periods as well. On the other hand, if the agent misreports his/her type, then s/he can keep benefiting from easy tasks in the following periods.

This misreporting behavior caused by the additional deceiving benefit arising from the dynamic nature is the ratchet effect problem. If the principal wishes to deter misreporting in the first period (i.e., to deter the ratchet effect), then the principal needs to provide additional rent compared to a static adverse selection problem, so as to cover the entire deceiving benefit.

Seminal studies that point out the ratchet effect problem considered centrally planned economies (Cooper et al., 1999; Weitzman, 1980). As the formalization of this incentive problem proceeds, the ratchet effect problem was exported to market-based economic entities, such as firms.

The major research themes in the literature on the ratchet effect are (1) empirical investigations on whether the ratchet effect occurs consistently with the theoretical arguments, and (2) theoretical and empirical investigations on overcoming the ratchet effect problem. The remainder of this chapter reviews both of these research streams.

2.2. The Existence of the Ratchet Effect

Prior studies investigated whether the ratchet effect occurs as theoretically predicted. Since it is hard to know employees' true ability and discern whether employees strategically reduce their performance, it is difficult to identify the occurrence of the ratchet effect using non-experimental data (Cardella and Depew, 2018; Charness et al., 2011). Therefore, classical studies in this line of research primarily employ laboratory experiments.

For example, a classical experimental study was conducted by Chaudhuri (1998). They conducted a laboratory experiment in which the principal and agent contracted for two periods. At the beginning of the first period, the principal assigned a quota for the

agent and the agent produced an output. After observing the first period's output, the principal determined a new quota for the second period, and the agent responded with an output. The principal knew that there was an equal chance of the agent being either the high-cost type or the low-cost type, although the principal did not know the agent's exact type *ex-ante*.

Notably, in Chaudhuri's (1998) experimental design, the roles of the principal and the agent were both played by real participants. In addition, both players had a relatively high degree of freedom in their decision making, such that both the principal and the agent could select their decisions out of three alternatives in every period (i.e., there were $3 \times 3 \times 3 \times 3 = 81$ possible outcome passes).

As a result, Chaudhuri's (1998) findings did not provide strong evidence for the ratchet effect. The principals did not offer a quota, which is theoretically expected to be followed by a separating equilibrium, and the agents naively revealed their type even under a quota in which pooling was optimal for them.

The weakness of these results may be because of its complicated experimental design and lack of context (Charness et al., 2011). Since both the decisions of the principal and the agent were made by real participants with a lot of freedom, it was not easy for participants to understand the strategic nature of the experiment. Therefore, their decisions did not provide meaningful evidence of the ratchet effect.

Subsequently, Cooper et al. (1999) slightly improved this experimental design by adding context and reducing the burden of strategic thinking. Cooper et al. (1999) conducted experiments with students and experts who had extensive field experience with the ratchet effect (i.e., managers and white-collar workers in a state-owned company in the People's Republic of China). They compared the results not only based on the participants' characteristics, but also based on the existence of contexts. In addition, Cooper et al. (1999) reduced the complexity by standardizing the firm's second-period decision, thereby allowing participants to focus on the decisions of the first period. Although Cooper et al. (1999) could not find strong evidence of the ratchet effect, they concluded that it is more likely to be observed when context is provided in the case of expert sessions.

Charness et al. (2011) further simplified the experimental design and found the ratchet effect. In their experiment, participants were given the following context: a firm with food concession stands on campus was trying to contract a worker. The firm determined the rental fees of the stand considering the worker's talent. The worker decided his/her output level in response to the firm's decision on rental fees. If the worker had high talent, then s/he could accept both high rental fees and low rental fees.

In contrast, if the worker had low talent, then s/he could only accept low rental fees. Hence, the firm would have offered a high rental fee if s/he could infer that his/her worker was highly talented. Participants either assumed the role of the firm or that of a highly talented worker. To reduce strategic uncertainty, Charness et al. (2011) introduced a non-real player, and the role of a low-talent worker was played by a computer. In accordance with Cooper et al.'s (1999) approach, Charness et al. (2011) focused on the participants' decisions in the first period.

The results of Charness et al. (2011) revealed that the ratchet effect occurs in a laboratory. They created single-stage periods and two-stage periods and compared participants' behavior between these two periods. In the single-stage periods, participants experienced the one-shot contract; thus, there was no fear of the ratchet effect problem. In contrast, in the two-stage periods, participants experienced the two-period contract, and they were theoretically expected to hide their private information for the sake of the next period's low rental fee. Consistent to their predictions, participants were statistically significantly less likely to reveal their private information in the two-stage periods compared to the single-stage periods.

The most recent laboratory experiment on the ratchet effect was carried out by Cardella and Depew (2018). The novelty of their study is the real-effort task, which may contribute to the understanding of the strategic nature. They, too, found the ratchet effect.

In Cardella and Depew's (2018) experiment, each participant had to stuff and seal mailing envelopes for a certain period of time. Each participant's output is measured as the number of assembled envelopes within the time limit, and thus, there was no interdependency in the task. The pilot experiment was run without incentivizing participants based on their output in order to obtain performance data that reflected participants' true ability. Then, Cardella and Depew (2018) compared participants' performance under the piece-rate payment with the pilot's performance data. They found that participants' performance was statistically significantly reduced in this phase of the experiment compared to their performance in the pilot.

Following the evolution of experimental studies, recent accounting studies have started to examine the occurrence of the ratchet effect by using data from actual firms (Bouwens and Kroos, 2011; Leone and Rock, 2002).

Using business unit (BU) data from a large multinational company, Leone and Rock (2002) found the occurrence of the ratchet effect. They assumed that the BU managers' earnings were affected by both transitory and permanent factors, both of which had either a positive or negative impact on their earnings. If a positive transitory

factor is realized, managers have an incentive to offset this impact because it will lead to the upward revision of their next period's targets and a reduction in their bonus. Based on this, they predicted that BU managers could adjust their reported income by making income-decreasing discretionary accruals. By using a proxy for transitory positive earnings shocks, they found that BU managers make income-decreasing discretionary accruals when they face transitory positive shocks.

Bouwens and Kroos (2011) used store-level data from a retail company in the Netherlands. In their research site, each store manager was assigned a yearly sales target, and the target was determined based on their performance in the previous year. The store managers could earn bonuses based on the quarterly performance reviews. Bouwens and Kroos (2011) predicted that store managers with good year-to-date performance could reduce their end-of-year performance to avoid making the next period's target overly demanding. Consistent to their predictions, they found that the store managers who recorded good performance from the first to the third quarter would lower their end-of-year performance by reducing their effort in the final quarter.

2.3. Mitigating the Ratchet Effect

Previous literature theoretically proposed and empirically verified various ways to cope with the ratchet effect.

The most straightforward way considered in the literature is using the principal's commitment power. If a principal can commit not to revise targets upward, even after an agent records good performance, then revealing the true ability does not impair the agent's future utility (Aranda et al., 2014; Baron and Besanko, 1984; Bouwens et al., 2015; Indjejikian et al., 2014a; Indjejikian and Nanda, 2002). The logic here is the removal of the target revision itself, irrelevant of whether it is an individual or group work environment.

It is possible to reduce the ratchet effect without the principal's commitment power on some occasions. The existence of an outside option is one such possibility (Charness et al., 2011). If a principal has an outside option and an incumbent agent records bad performance, then the principal can get the agent fired and recruit a new agent. As a result, this fear of being fired decreases an agent's incentive to deceive. Charness et al. (2011) experimentally demonstrated that an outside option reduces the ratchet effect. The logic is the threat of replacement by an outside agent, whereby no interaction exists between the incumbent agent and the outside agent. Thus, this approach is basically toward the ratchet effect in individual work environments.

Limiting an agent's strategic influence on their future contracts is another

possibility (Cardella and Depew, 2018). Cardella and Depew (2018) considered a situation in which a principal contracts multiple agents, such that each agent conducts a real-effort task and performance is measured per person. Thus, their experimental task takes place in an independent work environment. They found that the ratchet effect is less likely to occur when the second period's contract, which is a piece rate amount per output, is designed per group and everyone is paid at the same rate as the rate determined per person. When the second period's rate is designed per group, even if an agent lowers their output in the first period, the second rate will decrease as long as the majority of the others record high output. Thus, the agents will not be better off by restricting their output in the first period. The logic here is to eliminate the agent's benefits from restricting output by reducing the degree to which the agent can influence their future contracts.

Utilizing peer performance information and filtering out common exogenous shocks is also an alternative possibility (Casas-Arce et al., 2018). They considered a situation in which the agent's output is determined by their effort and two random shocks, and the principal can only observe the output amount without knowing the effort level. One of the random shocks is common among agents, and the other one varies per person. The common shock is serially correlated, and the agent-specific shock is transitory. Casas-Arce et al. (2018) theoretically and empirically demonstrated that if a principal determines a target based not only on past output, but also on past peer output, then the ratchet effect is reduced. The logic is that contrasting past peer outcomes with those of the agent removes the impact of common shock and reduces information asymmetry between the principal and the agent. In Casas-Arce et al. (2018), the rationale for which the principal should reflect the peer's information is that the peer's information contains information for guessing the agent's private information, which is exogenously determined regardless of the peer's strategic decisions.

2.4. Inequity Aversion

Prior literature on the ratchet effect assumes that agents have a standard preference in that they only care about their own payoffs. Through experimental studies, however, it is now well recognized that some people may also care about others (Fehr and Schmidt, 2006; Cooper and Kagel, 2015). Such preferences are referred to as “other-regarding preferences” (or social preferences) (Dhami, 2016).

Inequity aversion is one type of other-regarding preference. Inequity-averse agents feel disutility when the payoffs are not equal among agents (Fehr and Schmidt, 2006; Cooper and Kagel, 2015).

Various formalizations of inequity aversion have been proposed (Bolton and Ockenfels, 2000; Engelmann and Strobel, 2004). For the purpose of measurability in a laboratory, Fehr and Schmidt's (1999) model of inequity-aversion was adopted in this research. Consider there are two agents: agent i and agent j . Let x_i be the agent i 's monetary rewards, then agent i 's utility u_i is

$$u_i = x_i - \alpha \max\{x_j - x_i, 0\} - \beta \max\{x_i - x_j, 0\} \quad (2.1)$$

where, $0 < \beta < \alpha$, and $\beta < 1$

Parameter α represents *envy*. Agent i suffers from envy when agent j gets more monetary rewards than agent i . Parameter β represents *guilt*. Agent i feels guilty when agent i gets more monetary rewards than agent j .

Various methods have been applied to measure parameters α and β in experimental studies (Bellemare et al., 2008). In this study, Blanco et al.'s (2011) method was adopted as it provides interval estimations for α and β of each subject, using a set of dictator games with binary choices. These estimations allow for an empirical analysis of each agent's behavior in the team-production task with respect to their inequity-aversion.

2.5. The Positioning of this Study

In this section, I will summarize the relationship between the above literature and this study in order to highlight the novelty of this research.

Most prior studies have investigated the ratchet effect in single-agent settings or multiple but independently working agents' settings. In single-agent settings, there is no room for interdependency between agents (Charness et al., 2011; Chaudhuri, 1998; Cooper et al., 1999; Weitzman, 1980). In multiple but independently working agent settings, each agent's output is determined and observed per person (Bouwens and Kroos, 2011; Cardella and Depew, 2018; Leone and Rock, 2002; Murphy, 2000). Therefore, in both cases, the impact of interdependency on production is not well considered.

The most closely related prior study is Casas-Arce et al. (2018). Assuming that there are multiple agents that work independently, Casas-Arce et al. (2018) demonstrated that contrasting outcomes between peers works to remove the impact of a common shock and to reduce information asymmetry, then the ratchet effect is reduced.

Although this logic and my study's logic are similar in a sense that there is some correlation among the employees' signals, the key difference is how peer's information becomes informative for guessing the employees' private information. In Casas-Arce et

al. (2018), peers' outcomes contain the same piece of information and thus the manager can remove it by cancelling them out. In contrast, in my study, simply canceling out peers' information does not reduce the information asymmetry, and the manager reduces it by directly utilizing the structure of the correlation.

In reference to the progress of experimental studies on the ratchet effect, this study adopts a simpler experimental design. Specifically, the role of the principal is played by a computer. In addition, the experimental instructions provided more context to facilitate participants' understanding.

In line with Cooper et al. (1999) and Charness et al.'s (2011) approach, this study focuses on participants' reporting behavior in the first period, which is a crucial factor in the ratchet effect problem.

3. A MODEL ON THE RATCHET EFFECT IN TEAMS WITH LEARNING

3.1. Introduction

This chapter presents a theoretical analysis to show how learning between teammates impacts the mechanism of the ratchet effect in teams.

Specifically, following prior literature (Charness et al., 2011; Lafont and Tirole, 1993; Weitzman 1980), I employ a dynamic adverse-selection model such that the principal and the agent contract with multiple periods and there is an information asymmetry on the agent's type. In addition, I bring in the concept of a team by assuming there are two agents and their team's output is interdependently determined depending on the two agents' effort levels following a Leontief-type production function.

The remainder of this chapter is organized as follows. Section 3.2 explains the basic settings of this model and Section 3.3 demonstrates the benchmark results. Section 3.4 analyzes the optimal contract within the class when the principal fully distinguishes the agent's type in the first period, and Section 3.5 analyzes the optimal contract within the class when the principal does not distinguish the type in the first period at all. Section 3.6 discusses the conditions in which the full-separation contract is feasible and compares the principal's expected utility under each contract. Then, Section 3.7 concludes.

3.2. The Setting of the Model⁴

Consider a situation where a principal manages a team with two agents ($n = 1, 2$) conducts a productive activity for two periods. Suppose every party is risk-neutral. Each

⁴ We can say this model captures the ratchet effect problem because that accompanies the following incentive problem. Since the principal cannot commit to any long-term contract, the principal revises the second period's contract considering the first period's results. If the good-type agent reveals their high-capability in the first period, then in the second period, the principal will assign the first-best offer which is tuned to the good-type agent's true capability. Such a first-best offer requires the agent to exert their maximum level of effort, while pays only the amount which just compensates their effort cost (it implies payment is minimum and the agents cannot enjoy rent). On the other hand, if the good-type agent misreports their type as bad, then in the second period, they will be assigned the first-best offer which is tuned to the bad-type agent's true capability. Since the good-type agent has higher capability than the bad-type agent, the good-type agent can achieve that effort requirement with lower cost and it renders some rent to the agent (i.e., if the good-type agent misreports their type in the first period, then they can earn some benefit in the second period). Thus, if the agents correctly expect what would happen in the second period, then they have an incentive to misreport their type in the first period for the sake of the second periods' rent.

agent exerts his own effort with private cost and the pair of two agents' efforts determine the team's output. Agent n 's effort in period t is $a_t^n \in [0, \bar{a}] \equiv A$. Let the output of the team in period t be $x_t = \min\{a_t^1, a_t^2\} \in X \subseteq \mathbb{R}$. Agents are heterogeneous in terms of their marginal cost of efforts. Suppose there are two types of agents: a good type and a bad type. Denote the type of agent n in period t as θ_t^n . Let $\theta_1^n \in \{\theta_G, \theta_B\}$ and $0 < \theta_G < \theta_B$. The cost of each agent is $C(a_t^n, \theta_t^n) = \theta_t^n a_t^n$. Therefore, θ_G means a low-cost and efficient type. Define the initial state of the team by the pair of team members' types in period 1 and denote it as $\omega^{ij} \equiv (\theta_1^1 = \theta_i, \theta_1^2 = \theta_j)$. Suppose $Pr(\omega^{ij}) = p_{ij} \geq 0$, $\sum_{ij} p_{ij} = 1$, $\sum_j p_{Gj} = \sum_i p_{iG} = p > 0$, and $\sum_j p_{Bj} = \sum_i p_{iB} = 1 - p$. Based on the team's output, income from the team's productive activity realizes. Let the team's income when the team's output is x_t be $b(x_t)$. Suppose $b(\cdot)$ is a twice continuously differentiable function. Let $b(0) = 0$, $b'(0) = +\infty$, $b'(\bar{x}) = 0$, for any $x < \bar{x}$, $b'(x) > 0$, and for any $x \geq 0$, $b''(x) \leq 0$. Agent n receives a reward w_t^n based on the team's output. The agents' utility in period t is determined by $w_t^n - \theta_t^n a_t^n$. The principal's utility in period t is determined by $b(x_t) - w_t^1 - w_t^2$. Suppose the principal cannot commit to any long-term contract. Therefore, she uses a short-term contract that can refine the contracts for the subsequent periods at the beginning of each period.

The timeline of this two-periods' transaction is as follows.

Period 0

1. Nature determines the type of agents. Each agent privately observes their own type.

Period 1

2. The principal offers a contract for two periods to both agents. If at least one of the agents rejects the contract, then everyone gets zero and the transaction ends.
3. If both agents accept the contract, then each agent submits a report on his type.
4. Based on agents' reports, the amount of outputs and rewards for the first period is determined. Agents produce outputs as prescribed in the selected contract. Thereafter, each party receives their payoff for the first period. Then, the first period ends.

Period 2

5. At the beginning of the second period, the ability improvement by learning arises if possible.
6. The principal offers a contract for the second period to both agents. If at least one of

the agents rejects the contract, then everyone receives zero and the transaction ends.

7. If both agents accept the contract, then each agent submits a report on his type.
8. Based on agents' reports, the contract to be executed is selected. Agents put in effort in the second period as prescribed in the selected contract and the team's output is realized. Thereafter, each party receives their payoff for the second period and the period ends.

Assumption 1 (Learning). *As a result of learning in the first period, at the beginning of the second period, the marginal cost of each agent improves as follows⁵.*

$$\begin{aligned}
\text{If } (\theta_1^1, \theta_1^2) &= (\theta_G, \theta_G), & \text{then } (\theta_2^1, \theta_2^2) &= (\theta_G - \epsilon, \theta_G - \epsilon) \\
\text{If } (\theta_1^1, \theta_1^2) &= (\theta_G, \theta_B), & \text{then } (\theta_2^1, \theta_2^2) &= (\theta_G - \epsilon, \theta_B - \epsilon - \Delta) \\
\text{If } (\theta_1^1, \theta_1^2) &= (\theta_B, \theta_G), & \text{then } (\theta_2^1, \theta_2^2) &= (\theta_B - \epsilon - \Delta, \theta_G - \epsilon) \\
\text{If } (\theta_1^1, \theta_1^2) &= (\theta_B, \theta_B), & \text{then } (\theta_2^1, \theta_2^2) &= (\theta_G - \epsilon, \theta_G - \epsilon)
\end{aligned}$$

where $\epsilon \geq 0$ and $0 \leq \Delta \leq \theta_B - \theta_G$.

3.3. Benchmark Analyses

Suppose the principal knows agents' types perfectly. Then, the principal offers the first-best contract, which is a solution of the following problem.

$$\max_{w, x} b(x_t) - w_t^1 - w_t^2 \quad \text{for } t = 1, 2 \quad (3.1)$$

$$\text{s.t. } w_t^n - \theta_t^n a_t^n \geq 0 \quad \text{for } n = 1, 2 \quad (3.2)$$

Let the first-best offer to the team with ω^{ij} be $\{x_t^{FB}(\omega^{ij}), a_t^{n, FB}(\omega^{ij}), w_t^{n, FB}(\omega^{ij})\}$ for any t and any n . The first-best offer satisfies the following lemma.

Lemma 1. *The first-best offer satisfies the following two properties.*

$$x_t(\omega^{ij}) = a_t^1(\omega^{ij}) = a_t^2(\omega^{ij}) \quad (3.3)$$

$$w_t^n(\omega^{ij}) = \theta_t^n a_t^n(\omega^{ij}) \quad \text{for } n = 1, 2 \quad (3.4)$$

The first property is driven by the characteristic of $x_t = \min\{a_t^1, a_t^2\}$. On one hand, by the construction of x_t , a higher effort by one of the agents does not contribute to increasing the team's output. Therefore, offering such a different effort would not improve the principal's income. On the other hand, a higher effort requires to increase

⁵ For simplicity, ϵ is zero in the experiment. In *NOLEARN*, $\Delta = 0$. Whereas in *LEARN*, $\Delta = \theta_B - \theta_G$.

rewards to that agent. Thus, if there is a difference in each agent's effort amount, such effort amounts never become optimal. The second property is driven by the binding of the participation constraints. This implies that any agent receives no rent under the first-best offer.

By Lemma 1, the characterization of the first-best offer is summarized in the following Proposition 1.

Proposition 1 (First-best Offer). *The first-best offer is characterized as follows.*

$$w_t^{n,FB}(\omega^{ij}) = \theta_t^n a_t^{n,FB}(\omega^{ij}) = \theta_t^n x_t^{FB}(\omega^{ij}) \quad \forall n, t, i, j \quad (3.5)$$

$$b'(x_t^{FB}(\omega^{ij})) = \theta_t^1 + \theta_t^2 \quad \forall t, i, j \quad (3.6)$$

3.4. Analyses on the Full-separating Short-term Contract

Hereafter, I analyze a case in which the principal cannot observe agents' types. Since this study assumes that the principal cannot commit to any long-term contract, the principal designs a short-term contract satisfying the incentive-compatibility constraints⁶.

This section shows the optimal short-term contract within the class of contracts which induces full separation in the first period. Full separation in the first period means that different type of agent takes different behavior in the first period and the principal can perfectly discern the agents' types based on their first period's behavior. Therefore, full separation corresponds to a situation in which the ratchet effect does not occur and the optimal contract shown in this section explains the way for the principal to deter the ratchet effect.

As in the benchmark case, any optimal short-term contract satisfies Lemma 2.

Lemma 2. *Any optimal short-term contract satisfies the following property.*

$$x_t(\omega^{ij}) = a_t^1(\omega^{ij}) = a_t^2(\omega^{ij}) \quad (3.7)$$

By Lemma 2, let the best fully separating short-term contract be $S^S = \{x_t^S(\omega^{ij}), w_t^{1,S}(\omega^{ij}), w_t^{2,S}(\omega^{ij})\}_{ij \in \{G,B\}, t=1,2}$.

I analyze the contract from the backward. Let me begin with the analyses of the second period. Since the agents' types are fully revealed as a result of the first period,

⁶ For simplicity, this study restricts its analysis to pure strategies. Thus this study does not deny the possibility that any partially-separating contract outperforms the other two contracts.

the principal knows the agent's type and there is no information asymmetry at this point. That is, the principal's problem in the second period is the same as the benchmark case. Therefore, the principal offers the first-best offer in the second period.

Proposition 2 (Second-period's Offer in Full Separation). *The optimal second period's offer in the full-separating contract is characterized as follows.*

$$w_2^{n,S}(\omega^{ij}) = w_2^{n,FB}(\omega^{ij}) = \theta_2^n x_2^{FB}(\omega^{ij}) \quad \forall n, i, j \quad (3.8)$$

$$b'(x_2^S(\omega^{ij})) = b'(x_2^{FB}(\omega^{ij})) = \theta_2^1 + \theta_2^2 \quad \forall i, j \quad (3.9)$$

Remember that the principal's utility in period t is determined by $b(x_t) - w_t^1 - w_t^2$. Denote a common discount factor by $\delta \in [0, 1]$. The principal designs the first period's offer so as to maximize the present value of the expected utility over two periods. Then, the principal's problem in the first period is formalized as follows.

$$\begin{aligned} \max_{w_1, x_1} \sum_{ij} p_{ij} [& b(x_1(\omega^{ij})) - w_1^1(\omega^{ij}) - w_1^2(\omega^{ij}) \\ & + \delta \{ b(x_2^{FB}(\omega^{ij})) - w_2^{1,FB}(\omega^{ij}) - w_2^{2,FB}(\omega^{ij}) \}] \end{aligned} \quad (3.10)$$

s. t.

$$\sum_j \frac{p_{Gj}}{p} [w_1^1(\omega^{Gj}) - \theta_G x_1(\omega^{Gj}) + \delta \times 0] \geq 0 \quad (3.11)$$

$$\sum_j \frac{p_{Bj}}{1-p} [w_1^1(\omega^{Bj}) - \theta_B x_1(\omega^{Bj}) + \delta \times 0] \geq 0 \quad (3.12)$$

$$\sum_i \frac{p_{iG}}{p} [w_1^2(\omega^{iG}) - \theta_G x_1(\omega^{iG}) + \delta \times 0] \geq 0 \quad (3.13)$$

$$\sum_i \frac{p_{iB}}{1-p} [w_1^2(\omega^{iB}) - \theta_B x_1(\omega^{iB}) + \delta \times 0] \geq 0 \quad (3.14)$$

$$\begin{aligned} & \sum_j \frac{p_{Gj}}{p} [w_1^1(\omega^{Gj}) - \theta_G x_1(\omega^{Gj}) + \delta \times 0] \\ & \geq \sum_j \frac{p_{Gj}}{p} [w_1^1(\omega^{Bj}) - \theta_G x_1(\omega^{Bj}) + \delta \{w_2^{1,FB}(\omega^{Bj}) - \theta_2^1 x_2^{FB}(\omega^{Bj})\}] \end{aligned} \quad (3.15)$$

$$\begin{aligned} & \sum_j \frac{p_{Bj}}{1-p} [w_1^1(\omega^{Bj}) - \theta_B x_1(\omega^{Bj}) + \delta \times 0] \\ & \geq \sum_j \frac{p_{Bj}}{1-p} [w_1^1(\omega^{Gj}) - \theta_B x_1(\omega^{Gj}) + \delta \{w_2^{1,FB}(\omega^{Gj}) - \theta_2^1 x_2^{FB}(\omega^{Gj})\}] \end{aligned} \quad (3.16)$$

$$\begin{aligned}
& \sum_i \frac{p_{iG}}{p} [w_1^2(\omega^{iG}) - \theta_G x_1(\omega^{iG}) + \delta \times 0] \\
& \geq \sum_i \frac{p_{iG}}{p} [w_1^2(\omega^{iB}) - \theta_G x_1(\omega^{iB}) + \delta \{w_2^{2,FB}(\omega^{iB}) - \theta_2^2 x_2^{FB}(\omega^{iB})\}] \quad (3.17)
\end{aligned}$$

$$\begin{aligned}
& \sum_i \frac{p_{iB}}{1-p} [w_1^2(\omega^{iB}) - \theta_B x_1(\omega^{iB}) + \delta \times 0] \\
& \geq \sum_i \frac{p_{iB}}{1-p} [w_1^2(\omega^{iG}) - \theta_B x_1(\omega^{iG}) + \delta \{w_2^{2,FB}(\omega^{iG}) - \theta_2^2 x_2^{FB}(\omega^{iG})\}] \quad (3.18)
\end{aligned}$$

Inequalities (3.11) to (3.14) are the participation contracts for each agent. Inequation (3.11) is the participation constraint for agent 1 when his type is good. Inequation (3.12) is the participation constraint for agent 1 when his type is bad. Inequalities (3.15) to (3.18) are the incentive-compatibility constraints for each agent. Inequation (3.15) is the incentive-compatibility constraint for agent 1 when his type is good. Inequation (3.16) is the incentive-compatibility constraint for agent 1 when his type is bad.

Substituting the second period's offer shown in Proposition 2 and reminding $0 < \theta_G < \theta_B$ and $0 \leq \Delta \leq \theta_B - \theta_G$, then the incentive-compatibility constraints (3.15) to (3.18) are rewritten as (3.19) to (3.22) respectively. Note here that, in the incentive-compatibility constraints for the bad type, the second period's utility of the right-hand side in the case that his teammate's type is bad is substituted to zero. This is because the second period's utility in that case is strictly negative. Since the second period's utility is lower than the reservation utility level of the shirking agent, the agent rejects the second period's offer and receives zero.

$$\begin{aligned}
& \sum_j \frac{p_{Gj}}{p} [w_1^1(\omega^{Gj}) - \theta_G x_1(\omega^{Gj})] \\
& \geq \frac{p_{GG}}{p} [w_1^1(\omega^{BG}) - \theta_G x_1(\omega^{BG}) + \delta(\theta_B - \theta_G - \Delta)x_2^{FB}(\omega^{BG})] \\
& \quad + \frac{p_{GB}}{p} [w_1^1(\omega^{BB}) - \theta_G x_1(\omega^{BB}) + \delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB})] \quad (3.19)
\end{aligned}$$

$$\begin{aligned}
& \sum_j \frac{p_{Bj}}{1-p} [w_1^1(\omega^{Bj}) - \theta_B x_1(\omega^{Bj})] \\
& \geq \frac{p_{BG}}{1-p} [w_1^1(\omega^{GG}) - \theta_B x_1(\omega^{GG}) + \delta\{\Delta - (\theta_B - \theta_G)\}x_2^{FB}(\omega^{GG})] \\
& \quad + \frac{p_{BB}}{1-p} [w_1^1(\omega^{GB}) - \theta_B x_1(\omega^{GB})] \quad (3.20)
\end{aligned}$$

$$\begin{aligned}
& \sum_i \frac{p_{iG}}{p} [w_1^2(\omega^{iG}) - \theta_G x_1(\omega^{iG})] \\
& \geq \frac{p_{GG}}{p} [w_1^2(\omega^{GB}) - \theta_G x_1(\omega^{GB}) + \delta(\theta_B - \theta_G - \Delta) x_2^{FB}(\omega^{GB})] \\
& \quad + \frac{p_{BG}}{p} [w_1^2(\omega^{BB}) - \theta_G x_1(\omega^{BB}) + \delta(\theta_B - \theta_G) x_2^{FB}(\omega^{BB})]
\end{aligned} \tag{3.21}$$

$$\begin{aligned}
& \sum_i \frac{p_{iB}}{1-p} [w_1^2(\omega^{iB}) - \theta_B x_1(\omega^{iB})] \\
& \geq \frac{p_{GB}}{1-p} [w_1^2(\omega^{GG}) - \theta_B x_1(\omega^{GG}) + \delta\{\Delta - (\theta_B - \theta_G)\} x_2^{FB}(\omega^{GG})] \\
& \quad + \frac{p_{BB}}{1-p} [w_1^2(\omega^{BG}) - \theta_B x_1(\omega^{BG})]
\end{aligned} \tag{3.22}$$

I analyze the optimal solution by ignoring the participation constraints for the good-type agent and the incentive-compatibility constraints for the bad-type agent: inequalities (3.11), (3.13), (3.20), and (3.22). The derived solution satisfies all of these omitted constraints.

The Lagrange function for this problem is written as follows.

$$\begin{aligned}
\mathcal{L}_{SEP} = & \sum_{ij} p_{ij} [b(x_1(\omega^{ij})) - w_1^1(\omega^{ij}) - w_1^2(\omega^{ij}) \\
& + \delta \{b(x_2^{FB}(\omega^{ij})) - w_2^{1,FB}(\omega^{ij}) - w_2^{2,FB}(\omega^{ij})\}] \\
& + \gamma_1 \left\{ \sum_j \frac{p_{Bj}}{1-p} [w_1^1(\omega^{Bj}) - \theta_B x_1(\omega^{Bj})] \right\} \\
& + \gamma_2 \left\{ \sum_i \frac{p_{iB}}{1-p} [w_1^2(\omega^{iB}) - \theta_B x_1(\omega^{iB})] \right\} \\
& + \lambda_1 \left\{ \sum_j \frac{p_{Gj}}{p} [w_1^1(\omega^{Gj}) - \theta_G x_1(\omega^{Gj})] \right. \\
& \quad - \frac{p_{GG}}{p} [w_1^1(\omega^{BG}) - \theta_G x_1(\omega^{BG}) + \delta(\theta_B - \theta_G - \Delta) x_2^{FB}(\omega^{BG})] \\
& \quad \left. - \frac{p_{GB}}{p} [w_1^1(\omega^{BB}) - \theta_G x_1(\omega^{BB}) + \delta(\theta_B - \theta_G) x_2^{FB}(\omega^{BB})] \right\} \\
& + \lambda_2 \left\{ \sum_i \frac{p_{iG}}{p} [w_1^2(\omega^{iG}) - \theta_G x_1(\omega^{iG})] \right. \\
& \quad \left. - \frac{p_{GG}}{p} [w_1^2(\omega^{GB}) - \theta_G x_1(\omega^{GB}) + \delta(\theta_B - \theta_G - \Delta) x_2^{FB}(\omega^{GB})] \right\}
\end{aligned}$$

$$-\frac{p_{BG}}{p} [w_1^2(\omega^{BB}) - \theta_G x_1(\omega^{BB}) + \delta(\theta_B - \theta_G) x_2^{FB}(\omega^{BB})] \} \quad (3.23)$$

From the Kuhn–Tucker conditions, the solution of this maximization problem satisfies the following (3.24) to (3.35). For convenience of representation, I denote the solution of this problem as $S_1^S = (\{x_1^S(\omega^{ij}), w_1^{1,S}(\omega^{ij}), w_1^{2,S}(\omega^{ij})\}_{ij \in \{G,B\}}, \gamma_1^S, \gamma_2^S, \lambda_1^S, \lambda_2^S)$.

$$\frac{\partial \mathcal{L}_{SEP}}{\partial x_1(\omega^{GG})}(S_1^S) = p_{GG} b'(x_1^S(\omega^{GG})) - \lambda_1^S \frac{p_{GG}}{p} \theta_G - \lambda_2^S \frac{p_{GG}}{p} \theta_G = 0 \quad (3.24)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial x_1(\omega^{GB})}(S_1^S) = p_{GB} b'(x_1^S(\omega^{GB})) - \gamma_2^S \frac{p_{GB}}{1-p} \theta_B - \lambda_1^S \frac{p_{GB}}{p} \theta_B - \lambda_2^S \frac{p_{GG}}{p} \theta_G = 0 \quad (3.25)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial x_1(\omega^{BG})}(S_1^S) = p_{BG} b'(x_1^S(\omega^{BG})) - \gamma_1^S \frac{p_{BG}}{1-p} \theta_B - \lambda_1^S \frac{p_{GG}}{p} \theta_G - \lambda_2^S \frac{p_{BG}}{p} \theta_G = 0 \quad (3.26)$$

$$\begin{aligned} \frac{\partial \mathcal{L}_{SEP}}{\partial x_1(\omega^{BB})}(S_1^S) &= p_{BB} b'(x_1^S(\omega^{BB})) - \gamma_1^S \frac{p_{BB}}{1-p} \theta_B - \gamma_2^S \frac{p_{BB}}{1-p} \theta_B - \lambda_1^S \frac{p_{GB}}{p} \theta_G \\ &\quad - \lambda_2^S \frac{p_{BG}}{p} \theta_G = 0 \end{aligned} \quad (3.27)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^1(\omega^{GG})}(S_1^S) = -p_{GG} + \lambda_1^S \frac{p_{GG}}{p} = 0 \quad (3.28)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^1(\omega^{GB})}(S_1^S) = -p_{GB} + \lambda_1^S \frac{p_{GB}}{p} = 0 \quad (3.29)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^1(\omega^{BG})}(S_1^S) = -p_{BG} + \gamma_1^S \frac{p_{BG}}{1-p} - \lambda_1^S \frac{p_{GG}}{p} = 0 \quad (3.30)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^1(\omega^{BB})}(S_1^S) = -p_{BB} + \gamma_1^S \frac{p_{BB}}{1-p} - \lambda_1^S \frac{p_{GB}}{p} = 0 \quad (3.31)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^2(\omega^{GG})}(S_1^S) = -p_{GG} + \lambda_1^S \frac{p_{GG}}{p} = 0 \quad (3.32)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^2(\omega^{GB})}(S_1^S) = -p_{GB} + \gamma_2^S \frac{p_{GB}}{1-p} - \lambda_2^S \frac{p_{BB}}{p} = 0 \quad (3.33)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^2(\omega^{BG})}(S_1^S) = -p_{BG} + \lambda_2^S \frac{p_{BG}}{p} = 0 \quad (3.34)$$

$$\frac{\partial \mathcal{L}_{SEP}}{\partial w_1^2(\omega^{BB})}(S_1^S) = -p_{BB} + \gamma_2^S \frac{p_{BB}}{1-p} - \lambda_2^S \frac{p_{BG}}{p} = 0 \quad (3.35)$$

For simplicity, suppose the agents' types are independent. Then, $p_{GG} = p^2, p_{GB} = p_{BG} = p(1-p), p_{BB} = (1-p)^2$.

From (3.24) to (3.35), we have

$$\gamma_1^S = \gamma_2^S = 1, \quad (3.36)$$

$$\lambda_1^S = \lambda_2^S = p > 0. \quad (3.37)$$

Substitute the above results into (3.24) to (3.27). Then, it yields that

$$b'(x_1^S(\omega^{GG})) = \theta_G + \theta_G, \quad (3.38)$$

$$b'(x_1^S(\omega^{GB})) = b'(x_1^S(\omega^{BG})) = \theta_G + \theta_B + \frac{p}{1-p}(\theta_B - \theta_G), \quad (3.39)$$

$$b'(x_1^S(\omega^{BB})) = \theta_B + \theta_B + \frac{2p}{1-p}(\theta_B - \theta_G). \quad (3.40)$$

Since both γ_1^S and γ_2^S are greater than zero, the participation constraints for the bad type bind at S_1^S . Then, we have

$$p[w_1^{1,S}(\omega^{BG}) - \theta_B x_1^S(\omega^{BG})] + (1-p)[w_1^{1,S}(\omega^{BB}) - \theta_B x_1^S(\omega^{BB})] = 0, \quad (3.41)$$

$$p[w_1^{2,S}(\omega^{GB}) - \theta_B x_1^S(\omega^{GB})] + (1-p)[w_1^{2,S}(\omega^{BB}) - \theta_B x_1^S(\omega^{BB})] = 0. \quad (3.42)$$

The following w^S s for the bad type satisfies the above binding conditions (3.41) and (3.42).

$$w_1^{1,S}(\omega^{Bj}) = \theta_B x_1^S(\omega^{Bj}) \quad j = G, B \quad (3.43)$$

$$w_1^{2,S}(\omega^{iB}) = \theta_B x_1^S(\omega^{iB}) \quad i = G, B \quad (3.44)$$

Since both λ_1^S and λ_2^S are greater than zero, the incentive-compatibility constraints for the good type bind at S_1^S . Then, we have

$$\begin{aligned} & p[w_1^{1,S}(\omega^{GG}) - \theta_G x_1^S(\omega^{GG})] + (1-p)[w_1^{1,S}(\omega^{GB}) - \theta_G x_1^S(\omega^{GB})] \\ &= p[w_1^{1,S}(\omega^{BG}) - \theta_G x_1^S(\omega^{BG}) + \delta(\theta_B - \theta_G - \Delta)x_2^{FB}(\omega^{BG})] \\ &+ (1-p)[w_1^{1,S}(\omega^{BB}) - \theta_G x_1^S(\omega^{BB}) + \delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB})], \text{ and} \end{aligned} \quad (3.45)$$

$$\begin{aligned} & p[w_1^{2,S}(\omega^{GG}) - \theta_G x_1^S(\omega^{GG})] + (1-p)[w_1^{2,S}(\omega^{GB}) - \theta_G x_1^S(\omega^{GB})] \\ &= p[w_1^{2,S}(\omega^{GB}) - \theta_G x_1^S(\omega^{GB}) + \delta(\theta_B - \theta_G - \Delta)x_2^{FB}(\omega^{GB})] \\ &+ (1-p)[w_1^{2,S}(\omega^{BB}) - \theta_G x_1^S(\omega^{BB}) + \delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB})]. \end{aligned} \quad (3.46)$$

It can be easily confirmed that the following w^S s for the good type satisfy the above binding incentive-compatibility constraints and all of the ignored constraints.

$$w_1^{1,S}(\omega^{GG}) = \theta_G x_1^S(\omega^{GG}) + (\theta_B - \theta_G)x_1^S(\omega^{BG}) + \delta(\theta_B - \theta_G - \Delta)x_2^{FB}(\omega^{BG}) \quad (3.47)$$

$$w_1^{1,S}(\omega^{GB}) = \theta_G x_1^S(\omega^{GB}) + (\theta_B - \theta_G)x_1^S(\omega^{BB}) + \delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB}) \quad (3.48)$$

$$w_1^{2,S}(\omega^{GG}) = \theta_G x_1^S(\omega^{GG}) + (\theta_B - \theta_G) x_1^S(\omega^{GB}) + \delta(\theta_B - \theta_G - \Delta) x_2^{FB}(\omega^{GB}) \quad (3.49)$$

$$w_1^{2,S}(\omega^{BG}) = \theta_G x_1^S(\omega^{BG}) + (\theta_B - \theta_G) x_1^S(\omega^{BB}) + \delta(\theta_B - \theta_G) x_2^{FB}(\omega^{BB}) \quad (3.50)$$

The above arguments are summarized in the following proposition.

Proposition 3 (First-period's Offer in Full Separation). *The optimal first period's offer in the full-separating contract is characterized as follows.*

$$b'(x_1^S(\omega^{GG})) = \theta_G + \theta_G \quad (3.51)$$

$$b'(x_1^S(\omega^{GB})) = b'(x_1^S(\omega^{BG})) = \theta_G + \theta_B + \frac{p}{1-p}(\theta_B - \theta_G) \quad (3.52)$$

$$b'(x_1^S(\omega^{BB})) = \theta_B + \theta_B + \frac{2p}{1-p}(\theta_B - \theta_G) \quad (3.53)$$

$$w_1^{1,S}(\omega^{GG}) = \theta_G x_1^S(\omega^{GG}) + (\theta_B - \theta_G) x_1^S(\omega^{BG}) + \delta(\theta_B - \theta_G - \Delta) x_2^{FB}(\omega^{BG}) \quad (3.54)$$

$$w_1^{1,S}(\omega^{GB}) = \theta_G x_1^S(\omega^{GB}) + (\theta_B - \theta_G) x_1^S(\omega^{BB}) + \delta(\theta_B - \theta_G) x_2^{FB}(\omega^{BB}) \quad (3.55)$$

$$w_1^{1,S}(\omega^{Bj}) = \theta_B x_1^S(\omega^{Bj}) \quad j = G, B \quad (3.56)$$

$$w_1^{2,S}(\omega^{GG}) = \theta_G x_1^S(\omega^{GG}) + (\theta_B - \theta_G) x_1^S(\omega^{GB}) + \delta(\theta_B - \theta_G - \Delta) x_2^{FB}(\omega^{GB}) \quad (3.57)$$

$$w_1^{2,S}(\omega^{BG}) = \theta_G x_1^S(\omega^{BG}) + (\theta_B - \theta_G) x_1^S(\omega^{BB}) + \delta(\theta_B - \theta_G) x_2^{FB}(\omega^{BB}) \quad (3.58)$$

$$w_1^{2,S}(\omega^{iB}) = \theta_B x_1^S(\omega^{iB}) \quad i = G, B \quad (3.59)$$

The above results show the following. First, the source of the ratchet effect is confirmed by comparing the above results with the second-best contract for a case when a principal-agent relationship is a one-shot relationship. The major difference between these two contracts is how much rent the good-type agent can earn. In the above full-separating contract, the good type receives more rent than in the one-shot case.

The reason for the above difference is as follows. In both cases, to induce agents to report their type truthfully, the principal needs to provide some rent which is at least as much as the benefit that agents can accrue by misreporting their types. If the good-type agents misreport their type as a bad type, then they will be assigned the first period's offer which is designed according to the bad-type agents' skill levels and the good-type agents can benefit from such an easy offer.

Moreover, in the case of a two-periods' relationship, misreporting his type in the first period renders benefit for the good-type agent not only in the first period but also in the second period. Since the principal does not have a commitment power, she will revise the second period's contract considering the revealed information as a result of the first period's agents' behavior. If the good-type agents report their type truthfully in

the first period, then they will face the first-best offer for the good-type agents in the second period and such an offer renders no informational rent to those agents. In contrast, if the good-type agents misreport their type as a bad type, then they will face the first-best offer for the bad-type agents in the second period and the good-type agents can benefit from such an easy offer again.

Therefore, in the two-period case, the principal needs to provide rent which covers the agent's deceiving benefit for the entire two periods. In other words, to prevent this rent-seeking behavior caused by the dynamics of the relationship (i.e., the ratchet effect), the principal needs to provide additional rent in the first period compared to a one-shot relationship case—at least as much as the agent's total deceiving benefit from two periods.

Second, the above results show that the more salient learning is, the more easily the principal can prevent the ratchet effect. How this statement is derived will be explained below.

The above result shows that the more the bad type who paired with the good type grows (i.e., as Δ becomes large), the less benefit the good-type agent can accrue by misreporting his type as the bad type. Suppose both agents are of the good type. In this case, the benefit of misreporting which the agent 1 can enjoy in the second period is $\delta(\theta_B - \theta_G - \Delta)x_2^{FB}(\omega^{BG})$. This term decreases as Δ increases. If Δ is at the minimum and equal to zero, then $\delta(\theta_B - \theta_G - \Delta)x_2^{FB}(\omega^{BG}) > 0$. If Δ is at the maximum and equal to $\theta_B - \theta_G$, then $\delta(\theta_B - \theta_G - \Delta)x_2^{FB}(\omega^{BG}) = 0$.

The logic of the above result is as follows. Since the principal knows when and how learning improves the agents' skill levels, she designs the second period's contract considering the skill improvement caused by learning. Thus, the principal assigns the second period's targets corresponding to the agents' skill levels in the second period.

In addition, the characteristic of learning which the bad-type agents grow more than any others drives the above benefit reduction. Given the above characteristic of learning, the principal knows that if one of the agents is a good type, then the other agent's skill level will be no less than $\theta_B - \epsilon - \Delta$ in the second period. Thus, if agent i reports his type as good and agent j reports his type as bad in the first period, then in the second period, the principal can assign a target corresponding to that skill level $\theta_B - \epsilon - \Delta$ for agent j . Therefore, even if the good-type agents misreport their type in the first period, as long as their teammate is a good type, those misreported agents will face a less easy target when $\Delta > 0$ than when $\Delta = 0$.

The above logic suggests that learning among teammates helps the principal to cope with the ratchet effect by introducing an additional correlation between the agents'

private information. In the presence of learning (i.e., $\Delta > 0$), the agents' skill level in the second period correlates because their skill improvement occurs depending on the pair of two agents' types. This additional correlation structure makes each agent's report on his own type informative not only about his own type but also about his teammate's type in the second period. Utilizing this additional correlation structure, the principal can reduce the informational rent to the good-type agents and cope with an information asymmetry problem more easily.

This result suggests that the firms can mitigate the ratchet effect by facilitating knowledge sharing among teammates to increase Δ and determining targets considering the skill improvement caused by learning.

3.5. Analyses on the Full-pooling Short-term Contract

In contrast to the previous section, this section shows the optimal short-term contract within the class of contracts which induces full pooling in the first period. Full pooling in the first period means that both types of agents take the same behavior in the first period and the principal cannot discern the agents' types based on their first period's behavior. Therefore, full pooling corresponds to a situation in which the ratchet effect occurs. Since distinguishing the agents' types requires the principal to owe informational rent and such required rent may become too large, the principal cannot bear such cost in some cases. Therefore, distinguishing the agents' types is not necessarily optimal for the principal. The optimal contract shown in this section explains what happens if the principal gives up to distinguish the agent's type in the first period at all.

Likewise in the analyses of the full-separation contract, Lemma 2 also stands in this case. Let $S^P = \{x_1^P, w_1^P, x_2^P(\omega^{ij}), w_2^{1,P}(\omega^{ij}), w_2^{2,P}(\omega^{ij})\}_{ij \in \{G,B\}}$ denote the optimal full-pooling short-term contract.

I analyze from the backward. Since the first period is full pooling, the principal designs the optimal contract for the second period based on the common prior p . The principal's problem is written as follows⁷.

$$\max_{w_2, x_2} \sum_{ij} p_{ij} \left[b(x_2(\omega^{ij})) - w_2^1(\omega^{ij}) - w_2^2(\omega^{ij}) \right] \quad (3.60)$$

⁷ Each constraint for the second-period analysis is written as an ex-post constraint. This assumption could be acceptable because agents may understand each other's ability by working together in the first period.

$$s. t. \ w_2^1(\omega^{Gj}) - (\theta_G - \epsilon)x_2(\omega^{Gj}) \geq 0 \quad j = G, B \quad (3.61)$$

$$w_2^1(\omega^{BG}) - (\theta_B - \epsilon - \Delta)x_2(\omega^{BG}) \geq 0 \quad (3.62)$$

$$w_2^n(\omega^{BB}) - (\theta_B - \epsilon)x_2(\omega^{BB}) \geq 0 \quad n = 1, 2 \quad (3.63)$$

$$w_2^2(\omega^{iG}) - (\theta_G - \epsilon)x_2(\omega^{iG}) \geq 0 \quad i = G, B \quad (3.64)$$

$$w_2^2(\omega^{GB}) - (\theta_B - \epsilon - \Delta)x_2(\omega^{GB}) \geq 0 \quad (3.65)$$

$$w_2^1(\omega^{Gj}) - (\theta_G - \epsilon)x_2(\omega^{Gj}) \geq w_2^1(\omega^{Bj}) - (\theta_G - \epsilon)x_2(\omega^{Bj}) \quad j = G, B \quad (3.66)$$

$$w_2^1(\omega^{BG}) - (\theta_B - \epsilon - \Delta)x_2(\omega^{BG}) \geq w_2^1(\omega^{GG}) - (\theta_B - \epsilon - \Delta)x_2(\omega^{GG}) \quad (3.67)$$

$$w_2^1(\omega^{BB}) - (\theta_B - \epsilon)x_2(\omega^{BB}) \geq w_2^1(\omega^{GB}) - (\theta_B - \epsilon)x_2(\omega^{GB}) \quad (3.68)$$

$$w_2^2(\omega^{iG}) - (\theta_G - \epsilon)x_2(\omega^{iG}) \geq w_2^2(\omega^{iB}) - (\theta_G - \epsilon)x_2(\omega^{iB}) \quad i = G, B \quad (3.69)$$

$$w_2^2(\omega^{GB}) - (\theta_B - \epsilon - \Delta)x_2(\omega^{GB}) \geq w_2^2(\omega^{GG}) - (\theta_B - \epsilon - \Delta)x_1(\omega^{GG}) \quad (3.70)$$

$$w_2^2(\omega^{BB}) - (\theta_B - \epsilon)x_1(\omega^{BB}) \geq w_2^1(\omega^{BG}) - (\theta_B - \epsilon)x_2(\omega^{BG}) \quad (3.71)$$

As in the analysis of the full-separation contract, I analyze the optimal solution by ignoring the participation constraints for the good type and the incentive-compatibility constraints for the bad type agent: inequalities (3.61), (3.64), (3.67), (3.68), (3.70), and (3.71). The derived solution satisfies all of these omitted constraints.

The Lagrange function for this problem is written as follows.

$$\begin{aligned} \mathcal{L}_{POOL} = & \sum_{ij} p_{ij} \left[b(x_2(\omega^{ij})) - w_2^1(\omega^{ij}) - w_2^2(\omega^{ij}) \right] \\ & + \mu_{1G} \{w_2^1(\omega^{BG}) - (\theta_B - \epsilon - \Delta)x_2(\omega^{BG})\} + \mu_{1B} \{w_2^1(\omega^{BB}) - (\theta_B - \epsilon)x_2(\omega^{BB})\} \\ & + \mu_{2G} \{w_2^2(\omega^{GB}) - (\theta_B - \epsilon - \Delta)x_2(\omega^{GB})\} + \mu_{2B} \{w_2^2(\omega^{BB}) - (\theta_B - \epsilon)x_2(\omega^{BB})\} \\ & + \xi_{1G} \{w_2^1(\omega^{GG}) - (\theta_G - \epsilon)x_2(\omega^{GG}) - w_2^1(\omega^{BG}) + (\theta_G - \epsilon)x_2(\omega^{BG})\} \\ & + \xi_{1B} \{w_2^1(\omega^{GB}) - (\theta_G - \epsilon)x_2(\omega^{GB}) - w_2^1(\omega^{BB}) + (\theta_G - \epsilon)x_2(\omega^{BB})\} \\ & + \xi_{2G} \{w_2^2(\omega^{GG}) - (\theta_G - \epsilon)x_2(\omega^{GG}) - w_2^2(\omega^{GB}) + (\theta_G - \epsilon)x_2(\omega^{GB})\} \\ & + \xi_{2B} \{w_2^2(\omega^{BG}) - (\theta_G - \epsilon)x_2(\omega^{BG}) - w_2^2(\omega^{BB}) + (\theta_G - \epsilon)x_2(\omega^{BB})\} \end{aligned} \quad (3.72)$$

From the Kuhn–Tucker conditions, the solution of this maximization problem satisfies the following (3.73) to (3.84). For the convenience of representation, I denote the solution of this problem $(\{x_2^P(\omega^{ij}), w_2^{1,P}(\omega^{ij}), w_2^{2,P}(\omega^{ij})\}_{i,j \in \{G,B\}}, \mu_{1G}^P, \mu_{1B}^P, \mu_{2G}^P, \mu_{2B}^P, \xi_{1G}^P, \xi_{1B}^P, \xi_{2G}^P, \xi_{2B}^P)$ as S_2^P .

$$\frac{\partial \mathcal{L}_{POOL}}{\partial x_2(\omega^{GG})}(S_2^P) = p_{GG}b'(x_2^P(\omega^{GG})) - \xi_{1G}^P\theta_G - \xi_{2G}^P\theta_G = 0 \quad (3.73)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial x_2(\omega^{GB})}(S_2^P) = p_{GB}b'(x_2^P(\omega^{GB})) - \mu_{2G}^P(\theta_B - \epsilon - \Delta) - \xi_{1B}^P\theta_G + \xi_{2G}^P\theta_G = 0 \quad (3.74)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial x_2(\omega^{BG})}(S_2^P) = p_{BG}b'(x_2^P(\omega^{BG})) - \mu_{1G}^P(\theta_B - \epsilon - \Delta) + \xi_{1G}^P\theta_G - \xi_{2B}^P\theta_G = 0 \quad (3.75)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial x_2(\omega^{BB})}(S_2^P) = p_{BB}b'(x_2^P(\omega^{BB})) - \mu_{1B}^P\theta_B - \mu_{2B}^P\theta_B + \xi_{1B}^P\theta_G + \xi_{2B}^P\theta_G = 0 \quad (3.76)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^1(\omega^{GG})}(S_2^P) = -p_{GG} + \xi_{1G}^P = 0 \quad (3.77)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^1(\omega^{GB})}(S_2^P) = -p_{GB} + \xi_{1B}^P = 0 \quad (3.78)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^1(\omega^{BG})}(S_2^P) = -p_{BG} + \mu_{1G}^P - \xi_{1G}^P = 0 \quad (3.79)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^1(\omega^{BB})}(S_2^P) = -p_{BB} + \mu_{1B}^P - \xi_{1B}^P = 0 \quad (3.80)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^2(\omega^{GG})}(S_2^P) = -p_{GG} + \xi_{12}^P = 0 \quad (3.81)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^2(\omega^{GB})}(S_2^P) = -p_{GB} + \mu_{2G}^P - \xi_{2G}^P = 0 \quad (3.82)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^2(\omega^{BG})}(S_2^P) = -p_{BG} + \xi_{2B}^P = 0 \quad (3.83)$$

$$\frac{\partial \mathcal{L}_{POOL}}{\partial w_2^2(\omega^{BB})}(S_2^P) = -p_{BB} + \mu_{2B}^P - \xi_{2B}^P = 0 \quad (3.84)$$

Remember that the agents' types are independent. From (3.77) to (3.84), we have

$$\mu_{1G}^P = \mu_{2G}^P = p > 0, \quad (3.85)$$

$$\mu_{1B}^P = \mu_{2B}^P = 1 - p, \quad (3.86)$$

$$\xi_{1G}^P = \xi_{2G}^P = p^2, \quad (3.87)$$

$$\xi_{1B}^P = \xi_{2B}^P = p(1 - p). \quad (3.88)$$

I substitute the above values into (3.73) to (3.76). Then, we obtain

$$b'(x_2^P(\omega^{GG})) = \theta_G - \epsilon + \theta_G - \epsilon, \quad (3.89)$$

$$b'(x_2^P(\omega^{GB})) = b'(x_2^P(\omega^{BG})) = \theta_G - \epsilon + \theta_B - \epsilon - \Delta + \frac{p}{1-p}(\theta_B - \theta_G - \Delta), \quad (3.90)$$

$$b'(x_2^P(\omega^{BB})) = \theta_B - \epsilon + \theta_B - \epsilon + \frac{2p}{1-p}(\theta_B - \theta_G). \quad (3.91)$$

Since μ_{1G}^P , μ_{1B}^P , μ_{2G}^P , and μ_{2B}^P are greater than zero, the participation constraints

for the bad type band at S_2^P . Hence, we have

$$w_2^{1,P}(\omega^{BG}) = (\theta_B - \epsilon - \Delta)x_2^P(\theta^{BG}), \quad (3.92)$$

$$w_2^{n,P}(\omega^{BB}) = (\theta_B - \epsilon)x_2^P(\omega^{BB}) \quad n = 1, 2, \quad (3.93)$$

$$w_2^{2,P}(\omega^{GB}) = (\theta_B - \epsilon - \Delta)x_2^P(\omega^{GB}). \quad (3.94)$$

Since ξ_{1G}^P , ξ_{1B}^P , ξ_{2G}^P , and ξ_{2B}^P are greater than zero, the incentive-compatibility constraints for the good type bind at S_2^P . Hence, we obtain

$$w_2^1(\omega^{GG}) - (\theta_G - \epsilon)x_2(\omega^{GG}) = w_2^1(\omega^{BG}) + (\theta_G - \epsilon)x_2(\omega^{BG}), \quad (3.95)$$

$$w_2^1(\omega^{GB}) - (\theta_G - \epsilon)x_2(\omega^{GB}) = w_2^1(\omega^{BB}) + (\theta_G - \epsilon)x_2(\omega^{BB}), \quad (3.96)$$

$$w_2^2(\omega^{GG}) - (\theta_G - \epsilon)x_2(\omega^{GG}) = w_2^2(\omega^{GB}) + (\theta_G - \epsilon)x_2(\omega^{GB}), \quad (3.97)$$

$$w_2^2(\omega^{BG}) - (\theta_G - \epsilon)x_2(\omega^{BG}) = w_2^2(\omega^{BB}) + (\theta_G - \epsilon)x_2(\omega^{BB}). \quad (3.98)$$

It can be easily confirmed that the following w^S s for the good type satisfy the above binding incentive-compatibility constraints and all of the ignored constraints.

$$w_2^{1,P}(\omega^{GG}) = (\theta_G - \epsilon)x_2^P(\omega^{GG}) + (\theta_B - \theta_G - \Delta)x_2^P(\omega^{BG}) \quad (3.99)$$

$$w_2^{1,P}(\omega^{GB}) = (\theta_G - \epsilon)x_2^P(\omega^{GB}) + (\theta_B - \theta_G)x_2^P(\omega^{BB}) \quad (3.100)$$

$$w_2^{2,P}(\omega^{GG}) = (\theta_G - \epsilon)x_2^P(\omega^{GG}) + (\theta_B - \theta_G - \Delta)x_2^P(\omega^{GB}) \quad (3.101)$$

$$w_2^{2,P}(\omega^{BG}) = (\theta_G - \epsilon)x_2^P(\omega^{BG}) + (\theta_B - \theta_G)x_2^P(\omega^{BB}) \quad (3.102)$$

The above arguments are summarized in the following proposition.

Proposition 4 (Second-period's Offer in Full Pooling). *The optimal second period's offer in the full-pooling contract is characterized as follows.*

$$b'(x_2^P(\omega^{GG})) = \theta_G - \epsilon + \theta_G - \epsilon \quad (3.103)$$

$$b'(x_2^P(\omega^{GB})) = b'(x_2^P(\omega^{BG})) = \theta_G - \epsilon + \theta_B - \epsilon - \Delta + \frac{p}{1-p}(\theta_B - \theta_G - \Delta) \quad (3.104)$$

$$b'(x_2^P(\omega^{BB})) = \theta_B - \epsilon + \theta_B - \epsilon + \frac{2p}{1-p}(\theta_B - \theta_G) \quad (3.105)$$

$$w_2^{1,P}(\omega^{GG}) = (\theta_G - \epsilon)x_2^P(\omega^{GG}) + (\theta_B - \theta_G - \Delta)x_2^P(\omega^{BG}) \quad (3.106)$$

$$w_2^{1,P}(\omega^{GB}) = (\theta_G - \epsilon)x_2^P(\omega^{GB}) + (\theta_B - \theta_G)x_2^P(\omega^{BB}) \quad (3.107)$$

$$w_2^{1,P}(\omega^{BG}) = (\theta_B - \epsilon - \Delta)x_2^P(\omega^{BG}) \quad (3.108)$$

$$w_2^{n,P}(\omega^{BB}) = (\theta_B - \epsilon)x_2^P(\omega^{BB}) \quad n = 1, 2 \quad (3.109)$$

$$w_2^{2,P}(\omega^{GG}) = (\theta_G - \epsilon)x_2^P(\omega^{GG}) + (\theta_B - \theta_G - \Delta)x_2^P(\omega^{GB}) \quad (3.110)$$

$$w_2^{2,P}(\omega^{BG}) = (\theta_G - \epsilon)x_2^P(\omega^{BG}) + (\theta_B - \theta_G)x_2^P(\omega^{BB}) \quad (3.111)$$

$$w_2^{2,P}(\omega^{GB}) = (\theta_B - \epsilon - \Delta)x_2^P(\omega^{GB}) \quad (3.112)$$

Now I move on to the analyses of the first period. The principal's problem in the first period is formalized as follows. Since the principal does not distinguish each agent's type at all in the first period, both types of agents are treated in the same way and there is no incentive compatibility constraint.

$$\max_{w_1, x_1} \sum_{ij} p_{ij} \left[b(x_1) - w_1 - w_1 + \delta \left\{ b \left(x_2^P(\omega^{ij}) \right) - w_2^{1,P}(\omega^{ij}) - w_2^{2,P}(\omega^{ij}) \right\} \right] \quad (3.113)$$

$$\text{s. t. } \sum_j \frac{p_{Gj}}{p} [w_1 - \theta_G x_1 + \delta \{ w_2^{1,P}(\omega^{Gj}) - (\theta_G - \epsilon) x_2^P(\omega^{Gj}) \}] \geq 0 \quad (3.114)$$

$$\sum_j \frac{p_{Bj}}{1-p} [w_1 - \theta_B x_1 + \delta \{ w_2^{1,P}(\omega^{Bj}) - \theta_2^1 x_2^P(\omega^{Bj}) \}] \geq 0 \quad (3.115)$$

$$\sum_i \frac{p_{iG}}{p} [w_1 - \theta_G x_1 + \delta \{ w_2^{2,P}(\omega^{iG}) - \theta_G x_2^P(\omega^{iG}) \}] \geq 0 \quad (3.116)$$

$$\sum_i \frac{p_{iB}}{1-p} [w_1 - \theta_B x_1 + \delta \{ w_2^{2,P}(\omega^{iB}) - \theta_2^2 x_2^P(\omega^{iB}) \}] \geq 0 \quad (3.117)$$

Inequalities (3.114) and (3.116) are rewritten as follows.

$$\begin{aligned} & \frac{p_{GG}}{p} [w_1 - \theta_G x_1 + \delta(\theta_B - \theta_G - \Delta) x_2^P(\omega^{BG})] \\ & + \frac{p_{GB}}{p} [w_1 - \theta_G x_1 + \delta(\theta_B - \theta_G) x_2^P(\omega^{BB})] \geq 0 \end{aligned} \quad (3.118)$$

$$\begin{aligned} & \frac{p_{GG}}{p} [w_1 - \theta_G x_1 + \delta(\theta_B - \theta_G - \Delta) x_2^P(\omega^{GB})] \\ & + \frac{p_{BG}}{p} [w_1 - \theta_G x_1 + \delta(\theta_B - \theta_G) x_2^P(\omega^{BB})] \geq 0 \end{aligned} \quad (3.119)$$

Rewriting inequalities (3.115) and (3.117), these inequalities become the following inequation.

$$w_1 - \theta_B x_1^P \geq 0 \quad (3.120)$$

I analyze the optimal solution by ignoring the participation constraints for the good type: inequalities (3.118) and (3.119). The derived solution satisfies all of these omitted constraints.

In so doing, the optimization problem becomes maximizing (3.113) subjective to (3.120).

Since inequation (3.120) binds at the optimal solution,

$$w_1^P = \theta_B x_1^P \quad (3.121)$$

To substitute the above solution into the objective function, the problem is rewritten as the following unconstrained optimization problem.

$$\max_{x_1} \sum_{ij} p_{ij} \left[b(x_1) - \theta_B x_1^P - \theta_B x_1^P + \delta \left\{ b(x_2^P(\omega^{ij})) - w_2^{1,P}(\omega^{ij}) - w_2^{2,P}(\omega^{ij}) \right\} \right] \quad (3.122)$$

By taking the first-order condition, we have

$$b'(x_1^P) = \theta_B + \theta_B. \quad (3.123)$$

The above solution satisfies every ignored constraint. The above arguments are summarized as the following proposition.

Proposition 5 (First-period's Offer in Full Pooling). *The optimal first period's offer in the full-pooling contract is characterized as follows.*

$$b'(x_1^P) = \theta_B + \theta_B \quad (3.124)$$

$$w_1^P = \theta_B x_1^P \quad (3.125)$$

3.6. Discussion

3.6.1. Feasibility of Full Separation

I discuss under what condition the principal can perfectly discern the agents' types in the first period. Full separation is feasible as long as the incentive-compatibility constraint for the bad type is satisfied. From (3.16), we have

$$p_{BG}[(\theta_B - \theta_G)\{x_1^S(\omega^{BG}) - x_1^S(\omega^{GG})\} + \delta(\theta_B - \theta_G - \Delta)\{x_2^{FB}(\omega^{BG}) - x_2^{FB}(\omega^{GG})\}] + p_{BB}[(\theta_B - \theta_G)\{x_1^S(\omega^{BB}) - x_1^S(\omega^{GB})\} + \delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB})] \leq 0. \quad (3.126)$$

Based on the assumptions on parameters, it is satisfied that $(\theta_B - \theta_G)\{x_1^S(\omega^{BG}) - x_1^S(\omega^{GG})\} < 0$, $\delta(\theta_B - \theta_G - \Delta)\{x_2^{FB}(\omega^{BG}) - x_2^{FB}(\omega^{GG})\} \leq 0$, $(\theta_B - \theta_G)\{x_1^S(\omega^{BB}) - x_1^S(\omega^{GB})\} < 0$, and $\delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB}) > 0$. Thus, if $\delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB})$ is significantly large, then the inequation (3.126) will not be satisfied.

Remember that $\delta(\theta_B - \theta_G)x_2^{FB}(\omega^{BB})$ is a part of the rent for the good-type agent in the first period when his teammate is the bad type and this rent is non-negative. The above inequality (3.126) suggests that if the rent for the good-type agent becomes sufficiently large, then full separation might not be feasible.

The intuition is as follows. If the principal provides sufficiently large rent to the agent who selects to report the good type in the first period, then not only the good-type agent but also the bad-type agent prefers to report the good type in the first period.

Since the main focus of this model analysis is the impact of learning, I investigate

how does learning (the parameter Δ) impact the feasibility of the full-separation contract using numerical examples. Specifically, I use the following two sets of parameters.

The first set of parameters is ($p = 0.3$, $\delta = 1$, $\theta_G = 0.1$, $\theta_B = 1$, $\epsilon = 0.01$). Figure 1 shows the left-hand side's value of inequation (3.126) depending on the value of Δ . It shows that inequation (3.126) is always satisfied for any possible value of Δ under these parameters. Figure 1 also shows that the more Δ increases the more the left-hand side's value gets close to the boundary of inequation (3.126).

Insert Figure 1 here

The second set of parameters is ($p = 0.3$, $\delta = 1$, $\theta_G = 0.7$, $\theta_B = 1$, $\epsilon = 0.01$). Under these parameters, inequation (3.126) is violated for some possible values of Δ as shown in Figure 2. Figure 2 shows that the more Δ increases the less the feasibility constraint is likely to be satisfied under these parameters.

Insert Figure 2 here

3.6.2. Comparison of Contracts

By comparing the principal's expected payoff under each contract, I discuss the optimality of each contract. Denote the present value of the principal's expected payoff for two periods under each contract as Π_{FB} , Π_{SEP} , and Π_{POOL} .

$$\begin{aligned} \Pi_{FB} = \sum_{ij} p_{ij} [& b(x_1^{FB}(\omega^{ij})) - w_1^{1,FB}(\omega^{ij}) - w_1^{2,FB}(\omega^{ij}) \\ & + \delta \{ b(x_2^{FB}(\omega^{ij})) - w_2^{1,FB}(\omega^{ij}) - w_2^{2,FB}(\omega^{ij}) \}] \end{aligned} \quad (3.127)$$

$$\begin{aligned} \Pi_{SEP} = \sum_{ij} p_{ij} [& b(x_1^S(\omega^{ij})) - w_1^{1,S}(\omega^{ij}) - w_1^{2,S}(\omega^{ij}) \\ & + \delta \{ b(x_2^{FB}(\omega^{ij})) - w_2^{1,FB}(\omega^{ij}) - w_2^{2,FB}(\omega^{ij}) \}] \end{aligned} \quad (3.128)$$

$$\Pi_{POOL} = b(x_1^P) - w_1^P - w_1^P + \delta \sum_{ij} p_{ij} [b(x_2^P(\omega^{ij})) - w_2^{1,P}(\omega^{ij}) - w_2^{2,P}(\omega^{ij})] \quad (3.129)$$

In the following, I numerically compare each contract. Specifically, I use two sets of parameters which I also used in the above.

Let me start with the first set of parameters ($p = 0.3$, $\delta = 1$, $\theta_G = 0.1$, $\theta_B = 1$, $\epsilon = 0.01$). As shown in Figure 1, the full-separation is always feasible under these parameters. Figure 3 shows the value of Π_{SEP} and Π_{POOL} depending on the value of

Δ . It shows that the full-separation contract outperforms the full-pooling contract if Δ is lower than a certain value. If Δ becomes larger than that certain value, the full-pooling contract outperforms the full-separation contract.

In the case of the second set of parameters ($p = 0.3$, $\delta = 1$, $\theta_G = 0.7$, $\theta_B = 1$, $\epsilon = 0.01$), the full-separation contract is not feasible in a certain region. Within the region where the full-separation contract is feasible, Figure 4 shows that the full-separation contract outperforms the full-pooling contract.

3.7. Conclusion

Using a dynamic adverse-selection model with a team, this chapter analyzes how learning between teammates impact the mechanism of the ratchet effect in teams.

The results of the model analysis show that learning helps the principal to cope with the ratchet effect by introducing an additional correlation between the agents' private information. This additional correlation makes each agent's report informative not only about his own type but also about his teammate's type in the second period. The principal can reduce the informational rent to the good-type agents by utilizing this correlation structure.

The practical implications of the above results are as follows. First, the firms can cope with the ratchet effect problem by facilitating employees' learning to increase Δ and determining targets considering the skill improvement caused by learning.

In addition, the results reveal an indirect benefit of learning to the firms. Facilitating employees' learning benefits to the firms not only by improving the skill level of unskilled employees but also by preventing skilled employees from slacking off and committing the ratchet effect.

4. AN EXPERIMENT ON THE RATCHET EFFECT IN TEAMS

4.1. Introduction

This chapter presents a laboratory experiment of a team-production task which is designed to test theoretical predictions on the mechanism of the ratchet effect in teams.

Using a laboratory experiment would be suitable for testing theoretical predictions on the ratchet effect. Since it is difficult to know the employees' true ability and discern whether the employees strategically reducing their performance, it is uneasy to identify the occurrence of the ratchet effect using non-experimental data (Cardella and Depew, 2018; Charness et al., 2011).

In this experiment, in line with the approach of Charness et al. (2011), I employed a contextful experimental design. Participants assume the role of the agents and I focused on type-reporting behaviors that the participants took in the task, and the principal's choices of targets given the reports were made by a computer program in the experiment⁸.

4.2. Experimental Design

This is a laboratory experiment using z-Tree (Fischbacher, 2007). The experiment has two parts. The first part is a team-production task. The second part is a measurement of the inequity aversion parameters α and β based on the BDM mechanism (Becker et al., 1964). In the following, I mainly explain the team-production task⁹.

4.2.1. The Team-Production Game

⁸ Suppose the role of the principal is also played by real participants. In this case, when participants for the role of the agents make decisions, they need to predict the strategic decision of the principal in addition to that of their teammates. This would be too demanding for participants. In contrast, if the role of the principal is played by a computer and their decision rule is clearly informed through the experimental instructions, then the participants only need to consider their teammates' strategic decisions. Since the main focus of the ratchet effect problem is the agent's behavior, I decided to let the principal as a computer. I operationalized the principal's decision as follows: I assumed the principal's utility is determined as profit minus the sum of rewards paid to the agents. Then, I analyzed the principal's on-the-pass-of-the-equilibria behaviors likewise in the equilibrium analyses in Appendix A. The computer principal is designed to take those on-the-pass-of-the-equilibria behaviors. The detail of the principal's decision rule is explained in subsection 4.2.1. This decision rule was informed to participants in the experimental instructions.

⁹ A procedure of the second part is explained in Appendix B.

First, I explain the team-production game that underlies the team-production task. The game is based on a two-period adverse selection model in which a principal contracts with two agents who work as a team as same as the model in Chapter 3. In this experiment, the role of the principal is played by a computer. Participants assume the role of an agent. In each period, each agent puts in their effort with some effort cost. The marginal cost differs depending on the agent type. There are two types: a low-cost type (i.e., a skilled worker) and a high-cost type (i.e., a newcomer). The type is the agents' private information. Knowing their own type, each agent sends an opinion on the production schedule. Based on the agents' reports, the principal executes the production schedule of the team that consists of the units of production and rewards for each agent. The team's output is determined based on the agents' efforts in a completely complementary manner. Both agents must exert the same level of effort required to derive the output amount.

Insert Figure 5 here

Figure 5 shows the flow of decisions in this game. In the beginning, each participant was privately informed of their own type. An agent is a skilled worker with probability two thirds and an agent is a newcomer with probability one thirds.

After informing the type, the first period starts. First, participants were told that to determine a team's production schedule, a manager asked workers' opinions on how much they could work in this period. Then, participants make the following decision simultaneously. Each participant selects one of the three alternatives to represent the opinion: *Much*, *Less*, or *Reject*¹⁰. The principal interprets the opinion such that selecting the alternative *Much* (*Less*) corresponds to reporting the type as a skilled worker (newcomer). Depending on the pair of participants' choices, the principal determines the units of production requirement for this team and rewards for each agent. Each agent bears effort costs by conducting a production activity. Agents' payoffs are calculated by subtracting the cost of production effort from the rewards¹¹. The units of production follow the following order: "the amount when both select *Much*" > "the amount when one selects *Much* and the other selects *Less*" > "the amount when both select *Less*" It

¹⁰ Four payoff charts (1st and 2nd period's payoff charts for each type of worker) are printed as a one-pager. I hand them out to each participant. Participants can refer to the payoff charts at any time during this task.

¹¹ To facilitate better understanding of participants, I do not show the units of production or rewards. Only payoffs are shown in the experimental payoff charts. The payoffs are calculated based on the full-separation contract shown in Chapter 3 assuming learning is the most salient (i.e., $\Delta = \theta_B - \theta_G$).

suggests that the production requirement becomes more demanding when the agent selects *Much* than when s/he selects *Less*. The cost of production effort depends on the units of production and the agent's type. The cost increases as the units of production increase and the newcomers bear more cost than the skilled workers when they conduct the same amount of production activity. As will be explained shortly, the agents' decisions in the first period impact their first and second period's payoffs, thus we can consider this experimental design captures the feature of the ratchet effect problem.

Insert Tables 1 and 2 here

After the first period's decision, participants were informed of their teammates' type.

Then, based on two participants' decisions in the first period, the second period's schedule is determined by the principal according to Tables 3 and 4. The principal assumes that the first period's decisions correctly revealed the agents' types as explained in the above, then the principal believes there is no information asymmetry with respect to the agents' types and offers the first-best production schedule that corresponds to the agents' type pair in the second period. In other words, the second period's contract becomes more demanding if the agents selected *Much* in the first period than if he/she selected *Less*. As will be explained shortly, the agents' payoffs are impacted by the principals' schedule selection. Participants know how their first period's decisions impact the second period's schedule and their payoffs before they make the first period's decision. Thus, the agents' decisions in the first period impact their second period's payoffs through the determination of the second period's production schedule, and the agents need to make their first period's decision considering its impact on their first and second period's payoffs.

Insert Tables 3 and 4 here

In the second period, participants make the following decision simultaneously, given the selected second period's schedule. Each participant selects one of two alternatives: *Accept* or *Reject*. If both participants select *Accept*, then both get non-zero payoffs. Otherwise, both payoffs are zero. The concrete payoffs are shown in Tables 5, 6, 7, and 8.

Insert Tables 5, 6, 7, and 8 here

After the second period's decision, all results were fed back to each participant. Then the game ends.

4.2.2. Treatments

There are three treatments with the between-subject design: *ONE*, *NOLEARN*,

and *LEARN*. The base treatment is *NOLEARN*, in which participants play the team-production game described above. *ONE* is a treatment manipulated such that participants play only the first period in the team-production game and there are no dynamics in the principal-agent relationship. *LEARN* is a treatment manipulated such that participants can improve their ability by learning over periods. The mechanism of learning here is consistent with the definition of learning that I analyze in Section 3. Specifically, when a newcomer is paired with a skilled worker, the newcomer learns from the skilled teammate in the first period and then attains the same ability level as the skilled worker in the second period. However, the skilled workers never learn from any type of teammate, and their ability levels remain the same in the second period¹². In this *LEARN* treatment, participants were informed of the outcome of learning after the end of the first period. More precisely, participants are first informed of the type of their teammates that are given at the beginning of the first period. Participants are then informed whether ability improvement occurs in their team, and if so, they are also told whose ability is improved.

In all three treatments, the team-production task had 20 rounds. In each round, two participants were randomly paired without knowing each other. The participants' types are assigned such that two-thirds of participants randomly selected in each session are assigned the role of a skilled worker and the remaining one-third are assigned the role of a newcomer. Over 20 rounds, the team is randomly rematched by rounds¹³. In addition, each participant's type is randomly re-assigned by rounds.

4.2.3. Participants and Sessions

Participants were undergraduate and graduate students of Osaka University in Japan. They are recruited via an online recruitment system for economic experiments (ORSEE) run by the Institute of Social and Economic Research at Osaka University¹⁴.

I ran two sessions per treatment (six sessions in total). Each recruited student was assigned to one of the six sessions. Each session was conducted with either 18 or 24 participants due to no shows. Participants are randomly assigned to a separate computer terminal and conduct tasks independently. Each session took 90–120 minutes, including

¹² In the experiment, I normalize $\epsilon = 0$ without loss of generality, and $\Delta = \theta_B - \theta_G$ to highlight the impact of learning.

¹³ The re-matching protocol that this study used allows the same participants to be matched as a team again.

¹⁴ This study received approval from the Institute of Social and Economic Research at Osaka University.

ex-post questionnaires.

4.2.4. Payment Scheme

From this experiment, every participant receives a sum of the show-up fee and rewards from the two tasks. The show-up fee is 800 JPY. The rewards from the team-production task are determined based on participants' earned payoffs in the following way. After the 20 rounds end, one round is randomly selected. Each participant's rewards from this task are determined according to their total payoffs in this selected round by converting one payoff point to one JPY.

The method of determining rewards from the second task is explained in Appendix B.

4.3. Equilibrium Predictions and Hypotheses

Using the team-production game, I derived hypotheses about the ratchet effect in teams and the impact of learning on the ratchet effect in teams. To derive these hypotheses, I used a game-theoretic equilibrium analysis.

Before conducting the analyses, I reconfirm the situations wherein the ratchet effect does and does not occur. As explained in Chapter 2, the ratchet effect is a problem in that a high-ability agent misreports their type as a low-ability one, and then the principal cannot properly adjust the team's production schedule based on the agents' ability. This problem is caused by the high-ability agent's incentive to pursue the information rent from being assigned a relatively easy task in the future periods. In the experiment, the ratchet effect occurs if both skilled workers and newcomers select the same alternative in the first period since the manager cannot obtain any additional information to distinguish each worker's type based on his/her first period's decisions. In contrast, the ratchet effect does not occur if each type of worker selects a different alternative in the first period since the manager can distinguish each worker's type based on his/her first period's decisions and assign the second period's schedule based on the true ability.

For the equilibrium analysis, I focus on the following two strategy profiles as the candidates for equilibria: separation and pooling¹⁵. Separation is a strategy profile in which skilled workers select *Much* and newcomers select *Less* in the first period, and everyone selects *Accept* in the second period. This separation corresponds to the situation wherein the ratchet effect does not occur. In this case, the manager assigns the

¹⁵ For simplicity, this study restricts its analysis to pure strategies.

second period's schedule corresponding to the pair of skills: (Skilled, Skilled), (New, Skilled), and (New, New). Pooling is a strategy profile in which both types of workers select *Less* in the first period, and everyone selects *Accept* in the second period. This pooling corresponds to the situation wherein the ratchet effect occurs. In this case, the manager can not obtain any additional information on the agents' types from the first period's behavior and will assign the second period's schedule based on the prior information.

Table 9 summarizes the results of the equilibrium analyses for each treatment¹⁶. It shows which strategy profile—separation or pooling—becomes an equilibrium in each case.

Insert Table 9 here

Based on the above equilibrium analyses, I derived the following three hypotheses that investigate the existence of the ratchet effect in teams and the mechanism of mitigating the ratchet effect in teams.

The first hypothesis intends to test the existence of the ratchet effect in teams, and it is built on the comparison of *ONE* and *NOLEARN* in the case of agents with standard preferences. The above equilibrium analysis shows that separation is the only equilibrium in *ONE*. The logic is as follows: if skilled workers select *Much* in the first period, then they will get either 560 or 615, depending on their teammates' choices. However, if skilled workers select *Less*, then they will receive either 500 or 427. Thus, skilled workers can strictly better off by selecting *Much* in *ONE*.

However, pooling is the only equilibrium in *NOLEARN*. If skilled workers select *Much* in the first period, then they will get either $560 + 440$ or $615 + 440$ in total, depending on their teammates' choices. However, if skilled workers select *Less*, then they will get either $500 + 773$ or $427 + 628$ in total, depending on their teammates' choices. Thus, skilled workers can be better off by selecting *Less* in *NOLEARN*.

The choice of *Less* by the skilled workers in *NOLEARN* is the ratchet effect. The logic of this behavior is as follows: if the skilled workers select *Less* in the first period, then the units of production in the first period become lower and their payoffs from the first period are lower—500 or 427 compared to 560 or 615. However, the choice of *Less* brings them higher rent in the second period: 773 or 628 compared to 440. This benefit outweighs the loss in the first period. Thus, skilled workers have an incentive to select *Less* in the first period. In contrast, in *ONE*, there is no such incentive for skilled workers since they do not have an opportunity to earn any information rent in the

¹⁶ All analyses are shown in Appendix A.

second period.

From the above, I derive H1. H1 is tested by observing that separation occurs in *ONE* and pooling occurs in *NOLEARN*, which confirms that pooling is driven by the dynamics of the relationship.

H1: *For self-regarding individuals, the ratchet effect occurs in a team without learning.*

The second hypothesis tests that learning mitigates the ratchet effect in teams and is built on the comparison of *NOLEARN* and *LEARN* in the case of agents with standard preferences. The equilibrium results reveal that there are two equilibria—separation and pooling—in *LEARN*.

The logic of separating equilibrium is as follows. The payoffs when they earn by selecting *Much* are the same as in the *NOLEARN* treatment. If skilled workers select *Much* in the first period, they will earn either $560 + 400$ or $615 + 400$ in total, depending on their teammates' decisions. However, if the skilled workers select *Less* in the first period, then their payoffs may differ from *NOLEARN*, depending on their teammate's decision. Specifically, the skilled workers will earn either $500 + 440$ or $427 + 628$ in total. In the second period, they will earn only 440 in *LEARN*, in contrast to 773 in *NOLEARN*, when their teammate selects *Much*. This is because the manager knows that the agent who selected *Less* will improve the ability by learning from their skilled teammate even if the agent initially has a low skill, and the manager assigns the second period's schedule considering that both agents have high skill. Thus, as long as their teammate selects *Much* in the first period, they will not get any additional rent in the second period. Hence, the skilled workers' benefit from selecting *Less* does not compensate for the loss in the first period and their incentive to select *Less* in the first period vanishes; the ratchet effect does not occur in *LEARN*.

The logic of the pooling equilibrium in *LEARN* is similar to that in *NOLEARN*. More precisely, in *LEARN*, the principal knows that the probability that both agents have high skill in the second period is $8/9$, much higher than that in *NOLEARN*. However, the principal still assigns the production schedule for two low-skilled agents in the second period fearing that both agents have low skill and reject the second period's schedule for high-skilled agents.

Given H1 is supported, if separation occurs in *NOLEARN*, then it implies that the ratchet effect is mitigated by the existence of learning. From the above, I derive H2. H2 is tested by observing that separation occurs in *LEARN* and pooling occurs in *NOLEARN*.

H2: *Given H1 is supported, for self-regarding individuals, the ratchet effect is less likely to occur in a team with learning than in cases without learning.*

The third hypothesis investigates the impact of inequity aversion on the existence of the ratchet effect in teams and is built on the comparative static analysis of equilibria in *NOLEARN* with respect to the inequity aversion of the agents. For analyzing inequity-averse agents' behavior, I assume that agents have Fehr and Schmidt's (1999) inequity-averse utility function, as shown in Equation (2.1). Figure 6 shows how the equilibria differ depending on the agents' inequity-aversion parameters¹⁷.

Insert Figure 6 here

The light gray region in Figure 6 shows the pair of α and β for which separation is an equilibrium, whereas pooling is not. In the medium gray region, both separation and pooling are equilibria. In the dark gray region, pooling is an equilibrium, whereas separation is not. Consistent with H1, the standard preference $(\alpha, \beta) = (0, 0)$ belongs to the dark gray region. The above results mean that even without learning, agents prefer to tell their type truthfully if they feel strong envy and guilt, and thus, the ratchet effect does not occur.

From the above, I derive H3. H3 is tested by observing that separation occurs in *NOLEARN* when participants' inequity-aversion parameters belong to the medium gray or light gray region of Figure 6. To do so, I investigated each participant's behavior paired with their inequity aversion. The inequity-aversion parameters are measured based on the second part of this experiment, as explained in Appendix B.

H3: *The ratchet effect does not occur for those who have strong inequity aversion.*

4.4. Results

The total number of participants was 126, of which 29.37% were female, and this proportion of female students is not far away from the population of Osaka University students (Osaka University, 2019). Table 10 shows the summary statistics. The observation unit of Table 10 is the decision of each round. Since 126 participants conduct 20 rounds of decisions, I have 2,520 observations in total. Recall that two-thirds of the participants become skilled workers and one-third of participants become newcomers in each round. For example, since *NOLEARN* has 48 participants in

¹⁷ For this equilibrium analysis, I put the following two assumptions. First, α and β are symmetric among agents. Second, the value of α and β are common knowledge.

total, there are 640 observations of skilled workers' decisions in the first period¹⁸. The average earnings of *ONE*, *NOLEARN*, and *LEARN* are 1,477.639 JPY, 1,936.292 JPY, and 1,962.095 JPY, respectively.

Based on Table 10, more than 90% of newcomers select *Less* in *ONE*, *NOLEARN*, and *LEARN* (90.8%, 96.9%, and 97.9%, respectively). However, skilled workers' behavior differs between *ONE* and *NOLEARN*. More than 90% of skilled workers in *ONE* select *Much* (98.3%), whereas skilled workers in *NOLEARN* select *Less* more than *Much* (81.6% select *Less*). These observations are consistent with H1. This implies that the ratchet effect does occur.

Additionally, the ratio of skilled workers who select *Much* in *LEARN* is higher than that in *NOLEARN* (67.5% vs. 18.4%). This observation is consistent with H2. This implies that skilled workers are less likely to misrepresent their type in *LEARN* than in *NOLEARN*, that is, the ratchet effect is less likely to occur in the presence of learning.

Table 10 also shows the average value of inequity aversion by treatment. Figure 7 shows the scatter plot of the pair of inequity-aversion parameters. Based on these results, I confirm that most of the participants are weakly inequity-averse or do not care for inequity at all. Therefore, inequity aversion does not relate to these participants' behavior.

Insert Table 10 and Figure 7 here

4.4.1. Definitions of Variables

Since each participant repeatedly conducted 20 rounds of decisions, each decision data might not be independent. To cope with this problem, I created the following two variables and used them for testing:

Denote the participant i 's observed choice frequency that they select *Much* in the first period when they are a skilled worker as $Rate_MuchSkilled_i$.

$$Rate_MuchSkilled_i = \frac{\sum_{t=1}^{20} \mathbb{I}(Decision1_{i,t} = Much, Role_{i,t} = Skilled)}{\sum_{t=1}^{20} \mathbb{I}(Role_{i,t} = Skilled)} \quad (6)$$

Both $\mathbb{I}(Decision1_{i,t} = Much, Role_{i,t} = Skilled)$ and $\mathbb{I}(Role_{i,t} = Skilled)$ are indicator functions that take 1 when the condition in each bracket is satisfied and 0 otherwise.

¹⁸ In *NOLEARN*, one newcomer who is paired with a newcomer selected *Reject* in the first period and that team did not experience the second period. Therefore, the number of observations of newcomers' decision in the second period is reduced to 318.

Likewise, I denote participant i 's observed choice frequency that they select *Less* in the first period when they are a newcomer as $Rate_LessNew_i$.

$$Rate_LessNew_i = \frac{\sum_{t=1}^{20} \mathbb{I}(Decision1_{i,t} = Less, Role_{i,t} = Newcomer)}{\sum_{t=1}^{20} \mathbb{I}(Role_{i,t} = Newcomer)} \quad (7)$$

There were two sessions per treatment. I examine whether a difference exists in the above two variables by session within the same treatment. Based on the Kolmogorov–Smirnov test, I did not find any statistically significant difference between sessions. Subsequently, I pooled the data by treatment.

4.4.2. Testing the Existence of the Ratchet Effect (H1 & H3)

I examined whether the ratchet effect is observed in teams comparing *ONE* and *NOLEARN*. Specifically, I examined (1) whether skilled workers are less likely to select *Much* in *NOLEARN* than in *ONE* and (2) whether newcomers are likely to select *Less* regardless of treatments. To do so, I compared the distribution of the observed choice frequency I defined above. Figures 8 and 9 show the empirical cumulative distribution functions of $Rate_MuchSkilled_i$ and, $Rate_LessNew_i$ respectively.

Insert Figure 8 and Figure 9 here

First, I examined the skilled workers' behavior. Figure 8 shows that more than 80% of participants in *ONE* always select *Much*. However, in *NOLEARN*, participants who always select the alternative *Much* are almost zero. Moreover, approximately 40% of participants always select *Less*. The results of the Kolmogorov–Smirnov test revealed that the empirical cumulative distribution function $Rate_MuchSkilled_i$ of *NOLEARN* is statistically significantly greater than that of *ONE* ($D = 0.93056$, $p = 3.368e - 16$, one-sided¹⁹). Table 11 shows that the Wilcoxon's rank-sum test also provides consistent statistically significant evidence ($W = 2368$, $p < 0.001$, one-sided). Based on these results, I conclude that skilled workers in *NOLEARN* are less likely to select *Much* compared to those in *ONE*.

Insert Table 11 here

Second, I examined the newcomers' behavior. Figure 9 shows that newcomers are highly likely to select *Less* in both *ONE* and *NOLEARN*. In both treatments, more than 60% of participants always selected *Less*. Consistent with the equilibrium predictions,

¹⁹ Since the data include ties, all of the Kolmogorov–Smirnov test results rely on bootstrapping for calculating the confidence interval. Likewise, for the Wilcoxon's rank-sum test, I assigned each observation in a tie its average rank and deflated the variance of test statistics considering the number of ties.

the results of the Kolmogorov–Smirnov test do not reveal any statistical difference in the empirical cumulative distribution function $Rate_LessNew_i$ of *ONE* and *NOLEARN* ($D = 0.18056$, $p = 0.5137$, two-sided). Likewise, the results of Wilcoxon’s rank-sum test also reveal that these two distributions do not statistically differ ($W = 1411$, $p = 0.0668$, two-sided). Based on these results, I conclude that newcomers are highly likely to select *Less*, and their behavior does not differ between *ONE* and *NOLEARN*.

The above results demonstrate that the ratchet effect occurs; thus, H1 is supported.

The analyses so far are based on the assumption that participants are self-regarding individuals. I make sure whether inequity-averse participants exist, and if so, how they behave. First, I divided participants of *NOLEARN* into two subsamples. Recall that separation can be an equilibrium when individuals’ inequity-aversion parameters belong to the light gray and medium gray regions of Figure 6. The downward-sloping line in Figure 7 shows the boundary of the medium gray and dark gray regions in Figure 6. Figure 7 shows that almost all participants do not belong to the medium gray region. Moreover, the only participant who belongs to the medium gray region is that of *LEARN*. Therefore, no participant in *NOLEARN* belongs to the medium gray region. From the above, I concluded that the behavior predicted in H3—that individuals refrain from committing the ratchet effect due to their strong inequity aversion—is not observed in this experiment.

4.4.3. Testing the Impact of Learning on the Ratchet Effect (H2)

I examined whether the ratchet effect is mitigated in the presence of learning by comparing *NOLEARN* and *LEARN*. Specifically, I examined (1) whether skilled workers are more likely to select *Much* in *LEARN* compared to *NOLEARN* and (2) whether newcomers are likely to select *Less* regardless of treatments.

First, I investigated the skilled workers’ behavior. Figure 8 shows that approximately 30% of participants in *LEARN* always select *Much*. In contrast, participants of *NOLEARN* who always select *Much* are less than 5%. The results of the Kolmogorov–Smirnov test revealed that the empirical cumulative distribution function $Rate_MuchSkilled_i$ of *LEARN* is statistically significantly less than that of *NOLEARN* ($D = 0.66071$, $p = 3.21e - 09$, one-sided). In addition, the Wilcoxon’s rank-sum test also provides consistent statistically significant evidence, as shown in Table 11 ($W = 1509.5$, $p < 0.001$, one-sided). Based on these results, I concluded that skilled workers in *LEARN* are more likely to select *Much* compared to those in *NOLEARN*.

Second, I examined the newcomers' behavior. Figure 9 shows that newcomers are highly likely to select *Less* in both treatments. In addition, the results of both the Kolmogorov–Smirnov test ($D = 0.047619$, $p = 0.823$, two-sided) and the Wilcoxon's rank-sum test ($W = 2142.5$, $p = 0.2912$, two-sided) revealed that the empirical cumulative distribution functions $Rate_LessNew_i$ of *NOLEARN* and *LEARN* are not statistically significantly different. Based on these results, I concluded that newcomers are highly likely to select *Less*, and their behavior does not differ between *NOLEARN* and *LEARN*.

In addition, I examined whether the presence of learning completely resolved the ratchet effect, comparing skilled workers' behavior in *LEARN* and *ONE*. The results of both the Kolmogorov–Smirnov test ($D = 0.57937$, $p = 4.46e - 06$, two-sided) and the Wilcoxon's rank-sum test ($W = 1892$, $p < 0.001$, one-sided) revealed that the empirical cumulative distribution functions $Rate_MuchSkilled_i$ of *LEARN* is statistically significantly less than that of *ONE*. These results imply that the presence of learning partially reduces the likelihood that the ratchet effect occurs

The reason why the ratchet effect is only partially reduced is asked for the following discussions. As the equilibrium analyses in Section 3 proved, both separation and pooling are equilibria in *LEARN*. Figure 8 shows that the empirical cumulative distribution function of $Rate_MuchSkilled_i$ of *LEARN* has two mass points. It suggests that both equilibria occur in the experiment. Although the difference is not statistically significant²⁰, Figure 10 shows two empirical cumulative distribution functions of $Rate_MuchSkilled_i$ of *LEARN* dividing them into the first-half rounds' data and the latter-half rounds' data. Figure 10 suggests that skilled workers in the latter-half rounds are more likely to select *Much* compared to those in the first-half rounds. This implies that separation is more likely to be selected over pooling as the rounds proceed. From the above, the reason for the partial reduction of the ratchet effect can be understood because of the multiple equilibria, and data is consistent with the theoretical predictions.

4.5. Conclusion

Using a laboratory experiment with graduate and undergraduate students, I tested the theoretical predictions on the mechanisms of the ratchet effect in teams.

The experimental results show that, first, the ratchet effect occurred in teams. I confirmed that participants' inequity aversions belong to a region where the ratchet

²⁰ The result of Kolmogorov–Smirnov test is as follows: $D = 0.19048$, $p = 0.2179$, one-sided.

effect is theoretically expected to occur.

Second, the ratchet effect was statistically significantly mitigated in the presence of learning compared to in the absence of learning. In addition, our results show that learning partially deterred the ratchet effect. A possible explanation of this partial reduction is multiple equilibria and I confirmed that participants seemed to shift from pooling to separation as the rounds go by.

The limitation of this experiment is that I could not test whether strong inequity aversion deters the ratchet effect. Since most of the participants were self-regarding individuals, future researches can investigate this prediction by recruiting strongly inequity averse individuals.

5. CONCLUSION

This dissertation theoretically and experimentally demonstrated that the mechanism of the ratchet effect in teams differs qualitatively from that in independent work environments.

First, I theoretically proved a novel way to deter the ratchet effect in teams. In teams, the principal can deter the ratchet effect by utilizing a correlation between the agents' private information which arises because of learning among teammates. In addition, I demonstrated that the agent's incentive to commit the ratchet effect in teams depends on the agents' inequity aversion and sufficiently inequity-averse agents lose their incentive.

Then, I ran a laboratory experiment to test these theoretical predictions. The results of the experiment demonstrate that the ratchet effect occurs in teams. I confirmed that participants' inequity-aversion levels were sufficiently low to fall within a range for which the ratchet effect is theoretically expected to occur. The results also reveal that the ratchet effect is significantly mitigated in the presence of learning compared to when learning is absent.

The contributions of this study are as follows. First, this study extends the literature on target ratcheting and the ratchet effect (e.g., Aranda et al., 2014; Bouwens and Kroos, 2011; Cardella and Depew, 2018; Casas-Arce et al., 2018; Chaudhuri, 1998; Charness et al., 2011; Cooper et al., 1999; Indjejikian and Nanda, 2002; Indjejikian et al., 2014b; Laffont and Tirole, 1993; Leone and Rock, 2002; Matějka, 2018; Weitzman, 1980) by demonstrating that the mechanism of the ratchet effect in teams differs from that of independent work environments.

This study theoretically explains that the ratchet effect is deterred in teams with strongly inequity-averse agents because such agents mutually govern their behavior. Due to inequity aversion and interdependent work environments, the employees' incentive to commit the ratchet effect in teams differs from that in independent work environments. Future researches can further investigate the impact of different other-regarding preferences to deepen our understanding of this incentive.

This study also theoretically and experimentally demonstrated that learning among teammates works as a tool for the principal to deter the ratchet effect by introducing a correlation between the agents' private information, which makes each agent's report on their own type informative of the other teammates' type. The firms can cope with the ratchet effect problem by determining their employees' targets considering possible skill improvement caused by learning.

Second, this study reveals the indirect benefit of employees' learning for firms, which is not well discussed in the prior literature on learning (e.g., Berg et al., 1996; Hamilton et al., 2003). The results imply that facilitating knowledge sharing among team members and/or providing mentoring opportunities for low-performing employees are beneficial to firms as a means of not only improving the employees' abilities but also preventing skilled employees from shirking.

The limitation of this dissertation is the following. First, the model in Chapter 3 is not completely solved in an analytical way. Because of the complexity, subsection 3.6.2 provides numerical analyses.

Second, the limitation of the experiment is that this experiment was not designed for directly testing the impact of inequity aversion on the ratchet effect. Based on the results of this experiment, I cannot conclude whether strictly inequity-averse individuals refrain from committing the ratchet effect. Future research can test this impact more directly by recruiting participants with various inequity aversion and comparing the behavior based on their inequity aversion.

REFERENCES

- Aranda, C., Arellano, J., & Davila, A. (2014). Ratcheting and the role of relative target setting. *The Accounting Review*, 89(4), 1197-1226.
- Baron, D. P., & Besanko, D. (1984). Regulation, asymmetric information, and auditing. *The RAND Journal of Economics*, 447-470.
- Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science*, 9(3), 226-232.
- Bellemare, C., Kröger, S., & Van Soest, A. (2008). Measuring inequity aversion in a heterogeneous population using experimental decisions and subjective probabilities. *Econometrica*, 76(4), 815-839.
- Berg, P., Appelbaum, E., Bailey, T., & Kalleberg, A. L. (1996). The performance effects of modular production in the apparel industry. *Industrial Relations: A Journal of Economy and Society*, 35(3), 356-373.
- Blanco, M., Engelmann, D., & Normann, H. T. (2011). A within-subject analysis of other-regarding preferences. *Games and Economic Behavior*, 72(2), 321-338.
- Bolton, G. E., & Ockenfels, A. (2000). ERC: A theory of equity, reciprocity, and competition. *American Economic Review*, 90(1), 166-193.
- Bouwens, J., Cardinaels, E., & Zhang, J. (2015). Principals and their car dealers: What

- do targets tell about their relation?. Available at SSRN 2617406.
- Bouwens, J., & Kroos, P. (2011). Target ratcheting and effort reduction. *Journal of Accounting and Economics*, 51(1-2), 171-185.
- Cardella, E., & Depew, B. (2018). Output restriction and the ratchet effect: Evidence from a real-effort work task. *Games and Economic Behavior*, 107, 182-202.
- Casas-Arce, P., Holzhacker, M., Mahlendorf, M. D., & Matějka, M. (2018). Relative performance evaluation and the ratchet effect. *Contemporary Accounting Research*, 35(4), 1702-1731.
- Chaudhuri, A. (1998). The ratchet principle in a principal agent game with unknown costs: an experimental analysis. *Journal of Economic Behavior & Organization*, 37(3), 291-304.
- Charness, G., Kuhn, P., & Villeval, M. C. (2011). Competition and the ratchet effect. *Journal of Labor Economics*, 29(3), 513-547.
- Cooper, D. J., Kagel, J. H., Lo, W., & Gu, Q. L. (1999). Gaming against managers in incentive systems: Experimental results with Chinese students and Chinese managers. *American Economic Review*, 89(4), 781-804.
- Dekker, H. C., Groot, T., & Schoute, M. (2012). Determining performance targets. *Behavioral Research in Accounting*, 24(2), 21-46.
- Dhami, S. (2016). The foundations of behavioral economic analysis. Oxford University Press.
- Engelmann, D., & Strobel, M. (2004). Inequality aversion, efficiency, and maximin preferences in simple distribution experiments. *American Economic Review*, 94(4), 857-869.
- Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics*, 114(3), 817-868.
- Fehr, E., & Schmidt, K. M. (2006). The economics of fairness, reciprocity and altruism—experimental evidence and new theories. *Handbook of the Economics of Giving, Altruism and Reciprocity*, 1, 615-691.
- Fischbacher, U. (2007). z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10(2), 171-178.
- Hamilton, B. H., Nickerson, J. A., & Owan, H. (2003). Team incentives and worker heterogeneity: An empirical analysis of the impact of teams on productivity and participation. *Journal of Political Economy*, 111(3), 465-497.
- Holmstrom, B. (1982). Moral hazard in teams. *The Bell Journal of Economics*, 324-340.
- Indjejikian, R. J., Matějka, M., Merchant, K. A., & Van der Stede, W. A. (2014a). Earnings targets and annual bonus incentives. *The Accounting Review*, 89(4),

1227-1258.

- Indjejikian, R. J., Matějka, M., & Schloetzer, J. D. (2014b). Target ratcheting and incentives: Theory, evidence, and new opportunities. *The Accounting Review*, 89(4), 1259-1267.
- Indjejikian, R. J., Nanda, D. (2002). Executive Target Bonuses and What They Imply about Performance Standards. *The Accounting Review*, 77(4), 793-819.
- Laffont, J. J., & Tirole, J. (1993). A theory of incentives in procurement and regulation. MIT press.
- Leone, A. J., & Rock, S. (2002). Empirical tests of budget ratcheting and its effect on managers' discretionary accrual choices. *Journal of Accounting and Economics*, 33(1), 43-67.
- Matějka, M. (2018). Target setting in multi-divisional organizations. *Journal of Management Accounting Research*, 30(3), 13-27.
- Merchant, K. A., Stringer, C., & Shantapriyan, P. (2018). Setting Financial Performance Thresholds, Targets, and Maximums in Bonus Plans. *Journal of Management Accounting Research*, 30(3), 55-73.
- Merchant, K. A., & Van der Stede, W. A. (2017). Management control systems: performance measurement, evaluation and incentives (4th edition). Pearson Education.
- Murphy, K. J. (2000). Performance standards in incentive contracts. *Journal of Accounting and Economics*, 30(3), 245-278.
- Osaka University. (2019). Student Numbers: As of May 1, 2019. Retrieved from <https://www.osaka-u.ac.jp/en/guide/about/data/students.html>
- Weitzman, M. L. (1980). The "ratchet principle" and performance incentives. *The Bell Journal of Economics*, 302-308.

FIGURES

Figure 1: The Feasibility of the Full-separation Contract when $p = 0.3$, $\delta = 1$, $\theta_G = 0.1$, $\theta_B = 1$, $\epsilon = 0.01$

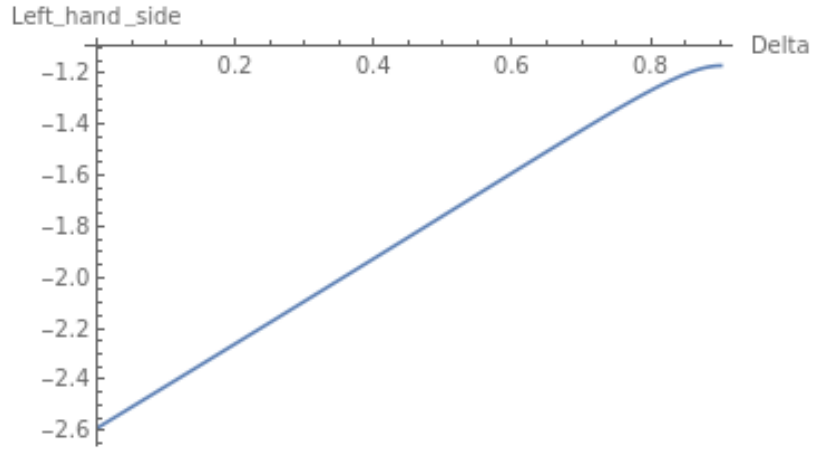


Figure 2: The Feasibility of the Full-separation Contract when $p = 0.3$, $\delta = 1$, $\theta_G = 0.7$, $\theta_B = 1$, $\epsilon = 0.01$

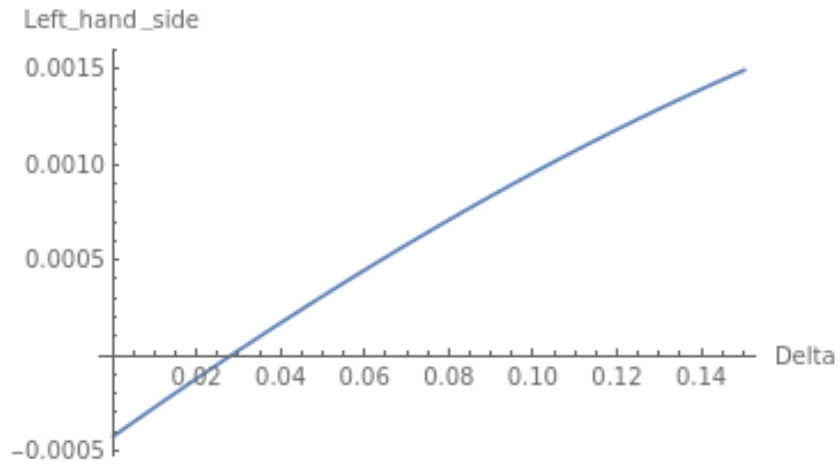


Figure 3: Π_{SEP} and Π_{POOL} when $p = 0.3$, $\delta = 1$, $\theta_G = 0.1$, $\theta_B = 1$, $\epsilon = 0.01$

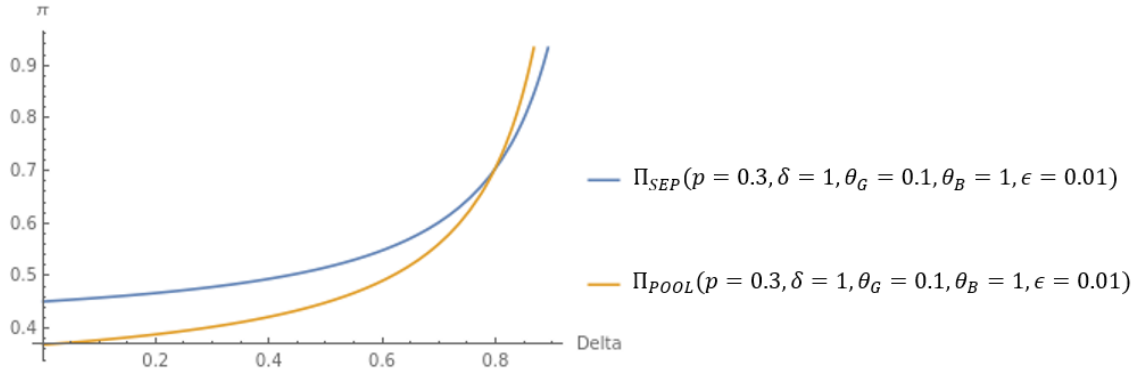


Figure 4: Π_{SEP} and Π_{POOL} when $p = 0.3$, $\delta = 1$, $\theta_G = 0.7$, $\theta_B = 1$, $\epsilon = 0.01$

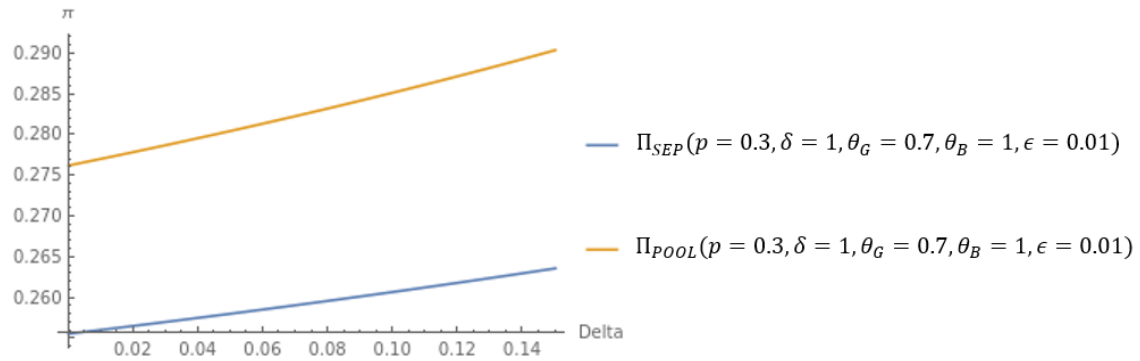
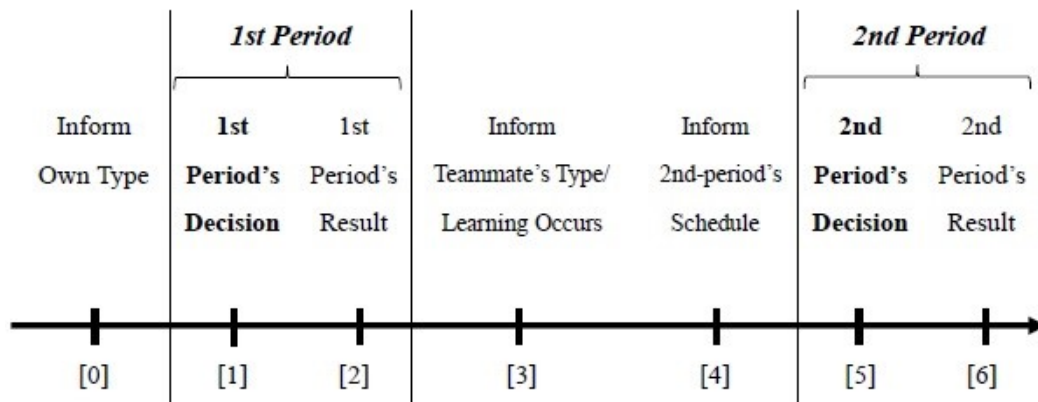
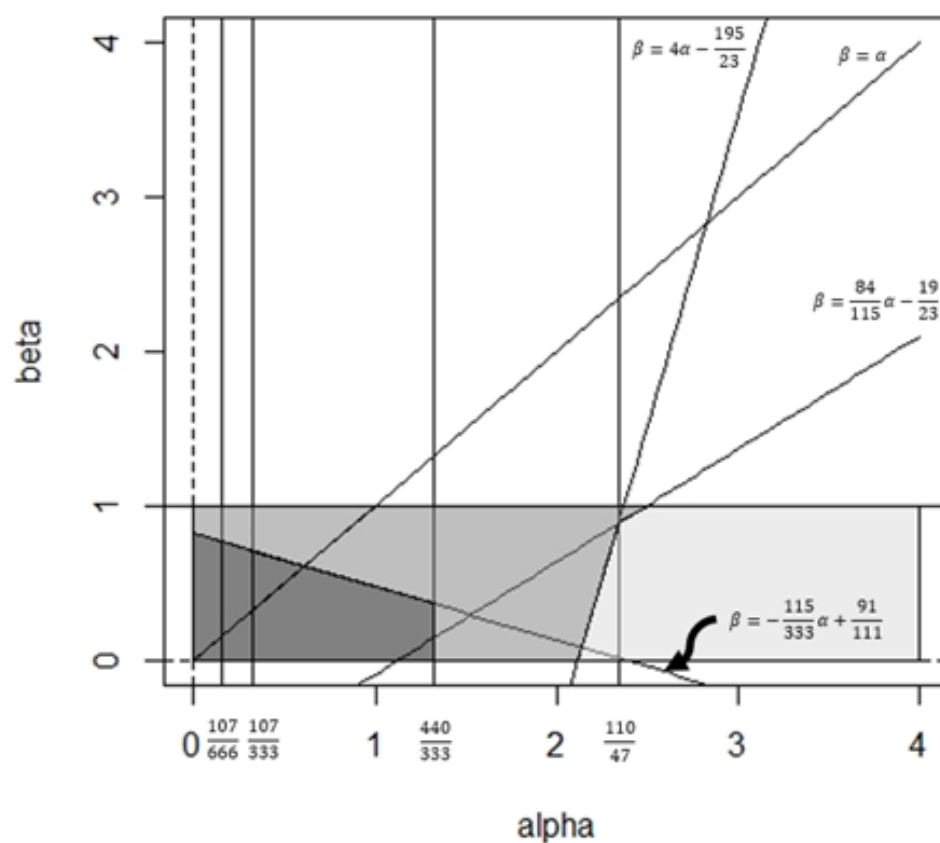


Figure 5: Timeline of a Round in Two-periods Treatments



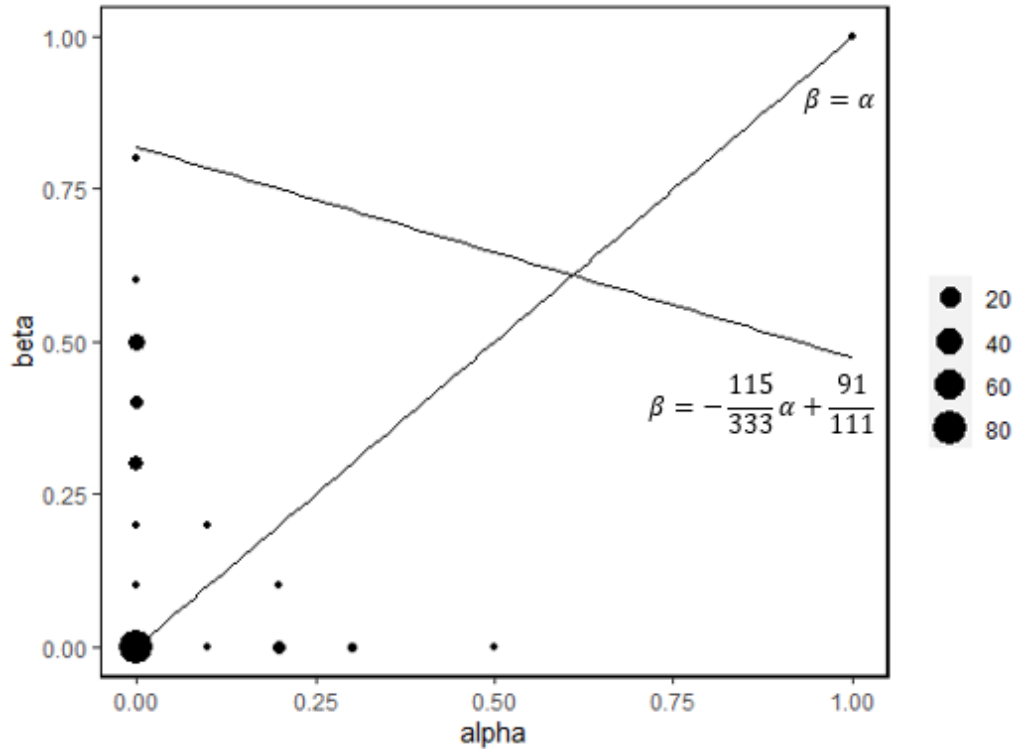
NOTE: At the timing of 3, learning occurs only in *LEARN* treatment.

Figure 6: Equilibriums in NOLEARN depending on the Inequity Aversion



NOTE: [Dark gray] pooling is an equilibrium while separation is not, [Medium gray] both pooling and separation is an equilibrium, [Light gray] separation is an equilibrium while pooling is not.

Figure 7: The Scatter Plot of Participants' Inequity Aversion



NOTE: The values of α and β are calculated as shown in Appendix C. These two parameters can take a value from 0 to 1 at an interval of 0.1. Two participants who represent more than two switching points are omitted; thus, the total observation number is 124. The number of participants who have $(\alpha, \beta) = (0,0)$ is 84. The number of participants who have $(\alpha, \beta) = (1,1)$ is 1 and that participant participates in the *LEARN* treatment.

Figure 8: The Empirical Cumulative Distribution Functions of Skilled Workers' Decisions in the First Period

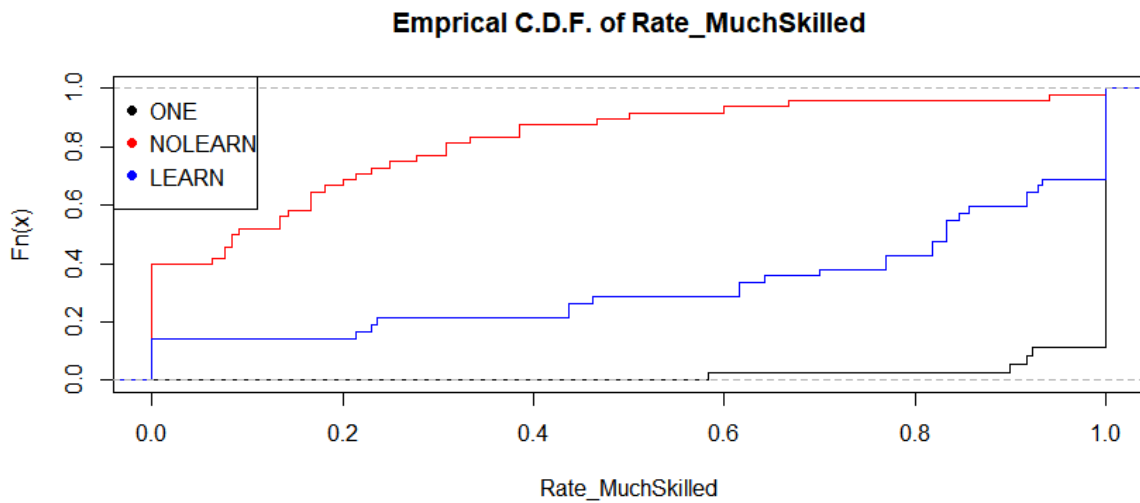


Figure 9: The Empirical Cumulative Distribution Functions of Newcomers' Decisions in the First Period

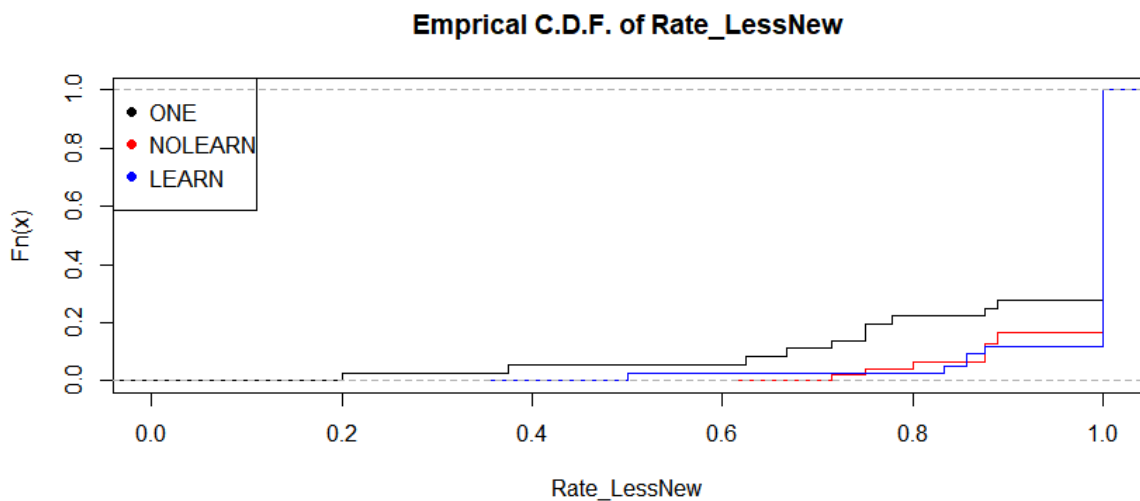
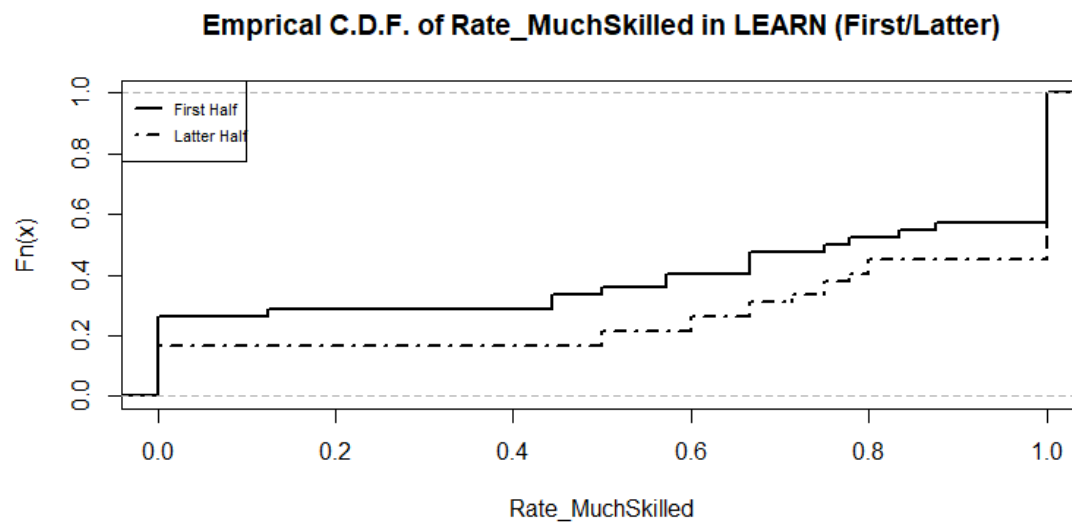


Figure 10: The Empirical Distribution Functions of Skilled Workers' First Period's Decisions in LEARN Treatment—Comparison of 1–10 Rounds' Data and 11–20 Rounds' Data—



TABLES

Table 1: A Payoff Chart for the First period's Decision when a Decision-maker is a Skilled Worker

Your Choice	Teammate's Choice	Your Payoff	Teammate's Payoff (if a skilled worker)	Teammate's Payoff (if a newcomer)
<i>Much</i>	<i>Much</i>	560	560	-190
	<i>Less</i>	615	500	380
	<i>Reject</i>	0	0	0
<i>Less</i>	<i>Much</i>	500	615	495
	<i>Less</i>	427	427	380
	<i>Reject</i>	0	0	0
<i>Reject</i>	-	0	0	0

Table 2: A Payoff Chart for the First period's Decision when a Decision-maker is a Newcomer

Your Choice	Teammate's Choice	Your Payoff	Teammate's Payoff (if a skilled worker)	Teammate's Payoff (if a newcomer)
<i>Much</i>	<i>Much</i>	-190	560	-190
	<i>Less</i>	495	500	380
	<i>Reject</i>	0	0	0
<i>Less</i>	<i>Much</i>	380	615	495
	<i>Less</i>	380	427	380
	<i>Reject</i>	0	0	0
<i>Reject</i>	-	0	0	0

Table 3: The Relationship between the First Period's Decisions and the Second Schedule in NOLEARN

Your Choice in the First Period	Teammate's Choice in the First Period	The Second Period's Schedule
<i>Much</i>	<i>Much</i>	A
<i>Much</i>	<i>Less</i>	B
<i>Less</i>	<i>Much</i>	C
<i>Less</i>	<i>Less</i>	D

Table 4: The Relationship between the First Decisions and the Second Schedule in LEARN

Your Choice in the First Period	Teammate's Choice in the First Period	The Second Period's Schedule
<i>Much</i>	<i>Much</i>	X
<i>Much</i>	<i>Less</i>	
<i>Less</i>	<i>Much</i>	
<i>Less</i>	<i>Less</i>	Y

Table 5: A Payoff Chart for the Second period's Decision when a Decision-maker is a Skilled Worker in NOLEARN

2 nd period's Schedule	Choices of You and Teammate	Your Payoff	Teammate's Payoff (if a skilled worker)	Teammate's Payoff (if a newcomer)
A	Both <i>Accept</i>	440	440	-310
	Others	0	0	0
B	Both <i>Accept</i>	440	773	440
	Others	0	0	0
C	Both <i>Accept</i>	773	440	107
	Others	0	0	0
D	Both <i>Accept</i>	628	628	440
	Others	0	0	0

Table 6: A Payoff Chart for the Second period's Decision when a Decision-maker is a Newcomer in NOLEARN

2 nd period's Schedule	Choices of You and Teammate	Your Payoff	Teammate's Payoff (if a skilled worker)	Teammate's Payoff (if a newcomer)
A	Both <i>Accept</i>	-310	440	-310
	Others	0	0	0
B	Both <i>Accept</i>	107	773	440
	Others	0	0	0
C	Both <i>Accept</i>	440	440	107
	Others	0	0	0
D	Both <i>Accept</i>	440	628	440
	Others	0	0	0

Table 7: A Payoff Chart for the Second period's Decision when a Decision-maker is a Skilled Worker in LEARN

2 nd period's Schedule	Choices of You and Teammate	Your Payoff	Teammate's Payoff (if a skilled worker)	Teammate's Payoff (if a newcomer)
X	Both <i>Accept</i>	440	440	440
	Others	0	0	0
Y	Both <i>Accept</i>	628	628	628
	Others	0	0	0

Table 8: A Payoff Chart for the Second period's Decision when a Decision-maker is a Newcomer in LEARN

2 nd period's Schedule	Choices of You and Teammate	Teammate's Type	Your Payoff	Teammate's Payoff
X	Both <i>Accept</i>	Skilled worker	440	440
		Newcomer	-310	-310
	Others	-	0	0
Y	Both <i>Accept</i>	Skilled worker	628	628
		Newcomer	440	440
	Others	-	0	0

Table 9: Equilibriums in Each Treatment

	Self-regarding Agents	Inequity-averse Agents
<i>ONE</i>	Separation only	Separation only
<i>NOLEARN</i>	Pooling only	Separation and Pooling (Depending on parameters)
<i>LEARN</i>	Separation and Pooling	Separation and Pooling

Table 10: Summary Statistics

	<i>ONE</i>	<i>NOLEARN</i>	<i>LEARN</i>
<i>First period:</i>			
Skilled workers' choices:			
Much	472/480 (98.3)	118/640 (18.4)	378/560 (67.5)
Less	8/480 (1.7)	522/640 (81.6)	182/560 (32.5)
Reject	0/480 (0.0)	0/640 (0.0)	0/560 (0.0)
Newcomers' choices:			
Much	19/240 (7.9)	9/320 (2.8)	6/280 (2.1)
Less	218/240 (90.8)	310/320 (96.9)	274/280 (97.9)
Reject	3/240 (1.3)	1/320 (0.3)	0/280 (0.0)
<i>Second period:</i>			
Skilled workers' choices:			
Accept	-	637/640 (99.5)	558/560 (99.6)
Reject	-	3/640 (0.5)	2/560 (0.4)
Newcomers' choices:			
Accept	-	315/318 (99.1)	278/280 (99.3)
Reject	-	3/318 (0.9)	2/280 (0.7)
Average of α	0.029	0.034	0.067
Average of β	0.023	0.120	0.139
Average Earnings (JPY)	1477.639	1936.292	1962.095
Number of Participants	36	48	42

NOTE: Percentages are in parentheses.

Table 11: The Results of the Wilcoxon Rank-Sum Tests for Decisions in the First Period

	<i>Rate_MuchSkilled</i>		<i>Rate_LessNew</i>	
	Test Statistics	<i>p</i> -value	Test Statistics	<i>p</i> -value
ONE v.s. NOLEARN	W=2368	p<0.001, one-sided	W=1411	p=0.0668, two-sided
NOLEARN v.s. LEARN	W=1509.5	p<0.001, one-sided	W=2142.5	p=0.2912, two-sided
ONE v.s. LEARN	W=1892	p<0.001, one-sided		

APPENDIX

A. Equilibriums in Each Treatment

A.1. *ONE* with Self-regarding Individuals

Suppose the teammate reports his type truthfully. Let the skilled worker's expected utility when he selects *Much* be $u_1(\textit{Skilled}, \textit{Much})$. Then,

$$\begin{aligned} u_1(\textit{Skilled}, \textit{Much}) &= \frac{2}{3} \times 560 + \frac{1}{3} \times 615 \\ &> \frac{2}{3} \times 500 + \frac{1}{3} \times 427 = u_1(\textit{Skilled}, \textit{Less}) \end{aligned} \quad (\text{A.1})$$

Thus, skilled workers strictly prefer *Much*. Likewise, newcomers strictly prefer *Less* as shown in the following.

$$u_1(\textit{New}, \textit{Much}) = \frac{2}{3} \times (-190) + \frac{1}{3} \times 495 < 380 = u_1(\textit{New}, \textit{Less}) \quad (\text{A.2})$$

Hence, separation is an equilibrium in this case.

A.2. *NOLEARN* with Self-regarding Individuals

First, I confirm that the separation is not an equilibrium in this case. The analyses go from the backward as is usual.

In the second period, suppose the first period achieved the separation. In this situation, all agents face the first best offer for their true types. Then, the agents' expected utility is all the same no matter what their true type is. The agents' expected utility when they select *Accept* is 440 and this is strictly larger than that in case they select *Reject*. Thus, every agent selects *Accept* in the second period.

Back to the first period, skilled workers' expected utility evaluated at the time of the first period²¹ is,

$$\begin{aligned} u_1(\textit{Skilled}, \textit{Much})_{SEP} &= \frac{2}{3}(560 + 440) + \frac{1}{3}(615 + 440) \\ &< \frac{2}{3}(500 + 773) + \frac{1}{3}(427 + 628) = u_1(\textit{Skilled}, \textit{Less})_{SEP} \end{aligned} \quad (\text{A.3})$$

Thus, skilled workers strictly prefer *Less* and the separation cannot be an equilibrium.

Next, I then confirm that the pooling is an equilibrium. Suppose every agent selects *Less* in the first period. In this situation, all agents face plan D in the second period.

²¹ For simplicity, I assume the common discount factor is equal to 1.

Skilled workers' expected utility when they select *Accept* is 628 and is strictly greater than that when they select *Reject*. Besides, newcomers' expected utility when they select *Accept* is 440 and is also strictly greater than what they can obtain when they select *Reject*. From the above, every agent strictly prefers *Accept* in the second period.

In the first period, skilled workers' expected utility evaluated at the time of the first period is,

$$\begin{aligned} u_1(\textit{Skilled}, \textit{Much})_{POOL} &= \frac{2}{3}(615 + 440) + \frac{1}{3}(615 + 440) \\ &= \frac{2}{3}(427 + 628) + \frac{1}{3}(427 + 628) = u_1(\textit{Skilled}, \textit{Less})_{POOL} \end{aligned} \quad (\text{A.4})$$

Thus, skilled workers weakly prefer *Less*.

Whereas, newcomers strictly prefer *Less* as shown in the following.

$$\begin{aligned} u_1(\textit{New}, \textit{Much})_{POOL} &= \frac{2}{3}(495 - 330) + \frac{1}{3}(495 - 330) \\ &< \frac{2}{3}(380 + 440) + \frac{1}{3}(380 + 440) = u_1(\textit{New}, \textit{Less})_{POOL} \end{aligned} \quad (\text{A.5})$$

Altogether, the pooling is an equilibrium in this case.

A.3. LEARN with Self-regarding Individuals

Suppose that every agent reports their type truthfully in the first period. In this case, all agents face the first best offer for their true type and such contract renders 440 when they select *Accept*. Thus, all agents strictly prefer *Accept* in the second period.

In the first period, skilled workers' expected utility is,

$$\begin{aligned} u_1(\textit{Skilled}, \textit{Much})_{SEP} &= \frac{2}{3}(560 + 440) + \frac{1}{3}(615 + 440) \\ &> \frac{2}{3}(500 + 440) + \frac{1}{3}(427 + 628) = u_1(\textit{Skilled}, \textit{Less})_{SEP} \end{aligned} \quad (\text{A.6})$$

Therefore, skilled workers strictly prefer *Much*. On the other hand, newcomers strictly prefer *Less*.

$$\begin{aligned} u_1(\textit{New}, \textit{Much})_{SEP} &= \frac{2}{3}(-190 + 440) + \frac{1}{3}(495 + 0) \\ &< \frac{2}{3}(380 + 628) + \frac{1}{3}(380 + 440) = u_1(\textit{New}, \textit{Less})_{SEP} \end{aligned} \quad (\text{A.7})$$

Hence, separation is an equilibrium in this case.

A.4. ONE with Inequity-averse Individuals

Suppose the agents have the inequity averse utility function as defined in the equation (2.1).

Skilled workers' expected utility when they select *Much* is,

$$u_1(\textit{Skilled}, \textit{Much}) = \frac{2}{3}[560] + \frac{1}{3}[615 - 235\beta] \quad (\text{A.8})$$

Whereas, their expected utility when they select *Less* is,

$$u_1(\textit{Skilled}, \textit{Less}) = \frac{2}{3}[500 - 115\alpha] + \frac{1}{3}[427 - 47\beta] \quad (\text{A.9})$$

Since $\beta < 1$, the value of the equation (A.8) is strictly greater than that of the equation (A.9) regardless of the pair of α and β . This implies that skilled workers always strictly prefer *Much* regardless of the extent of their inequity aversion.

Likewise, newcomers' expected utility when they select either *Much* or *Less* is,

$$u_1(\textit{New}, \textit{Much}) = \frac{2}{3}[-190 - 750\alpha] + \frac{1}{3}[495 - 115\beta] \quad (\text{A.10})$$

$$u_1(\textit{New}, \textit{Less}) = \frac{2}{3}[380 - 235\alpha] + \frac{1}{3}[380] \quad (\text{A.11})$$

Since both α and β are strictly greater than zero, the value of the equation (A.11) is always greater than that of the equation (A.10). Thus, newcomers strictly prefer *Less* regardless of their inequity averseness.

A.5. NOLEARN with Inequity-averse Individuals

First, I examine the separation equilibrium.

As in the above, I start with the analysis on the second period's on-the-pass-of-the-equilibrium behavior. Suppose every agent reports their type truthfully in the first period. Then, in the second period, all agents' expected utility when they select *Accept* is simply equal to 440. This is because everyone earns the same payoff and there is no room for the parameters α nor β impacts on. Thus, everyone strictly prefers *Accept*.

In the first period, skilled workers' expected utility when they select *Much* is,

$$u_1(\textit{Skilled}, \textit{Much})_{SEP} = \frac{2}{3}[560 + 440] + \frac{1}{3}[615 - 235\beta + 440] \quad (\text{A.12})$$

Whereas, their expected utility when they select *Less* differs depending on the second period's off-the-pass-of-the-equilibrium behavior. In the following, I analyze the condition when skilled workers prefer *Much* in each case.

[Case1: $\alpha \leq \frac{440}{333}$]

In this case, both types of agents select *Accept* in the second period. Thus, the skilled workers' expected utility when they select *Less* is,

$$u_1(\textit{Skilled}, \textit{Less})_{SEP} = \frac{2}{3} [500 - 115\alpha + 773 - 333\beta] + \frac{1}{3} [427 - 47\beta + 628 - 188\beta] \quad (\text{A.13})$$

Comparing (A.12) and (A.13), skilled workers weakly prefer *Much* as long as the following equation (A.14) is satisfied. Otherwise, they strictly prefer *Less*.

$$\beta \geq -\frac{115}{333}\alpha + \frac{91}{111} \quad (\text{A.14})$$

[Case2: $\frac{440}{333} < \alpha \leq \frac{110}{47}$]

In this case, newcomers select *Accept* in the second period likewise in Case 1. In contrast, skilled workers who selected on-the-pass-of-the-equilibrium behavior, *Much*, in the first period refuse to work in the second period. They select *Reject* because of their non-negligible envy. Since they will suffer sufficient envy over their teammate who took off-the-pass-of-the-equilibrium behavior in the first period, they prefer *Reject*. Thus, the skilled workers' expected utility when they select *Less* is,

$$u_1(\textit{Skilled}, \textit{Less})_{SEP} = \frac{2}{3} [500 - 115\alpha + 0] + \frac{1}{3} [427 - 47\beta + 628 - 188\beta] \quad (\text{A.15})$$

Comparing (A.12) and (A.15), skilled workers weakly prefer *Much* as long as the following equation (A.16) is satisfied. From the assumption, $\alpha \geq 0$. Thus, (A.16) is always satisfied.

$$\alpha \geq -\frac{100}{23} \quad (\text{A.16})$$

[Case3: $\frac{110}{47} < \alpha$]

In this case, skilled workers who selected on-the-pass-of-the-equilibrium behavior, *Much*, in the first period select *Reject* as in Case 2. In addition, newcomers who selected on-the-pass-of-the-equilibrium also become to select *Reject*. This is because of they will suffer non-negligible envy if they select *Accept*. Thus, the skilled workers' expected utility when they select *Less* is,

$$u_1(Skilled, Less)_{SEP} = \frac{2}{3}[500 - 115\alpha + 0] + \frac{1}{3}[427 - 47\beta + 0] \quad (A.17)$$

Comparing (A.12) and (A.17), skilled workers weakly prefer *Much* as long as the following equation (A.18) is satisfied.

$$\beta \leq \frac{115}{94}\alpha + \frac{407}{47} \quad (A.18)$$

Now we move on to the analyses of newcomers' behavior. Newcomers' on-the-pass-of-the-equilibrium expected utility is,

$$u_1(New, Less)_{SEP} = \frac{2}{3}[380 - 235\alpha + 440] + \frac{1}{3}[380 + 440] \quad (A.19)$$

Their off-the-pass-of-the-equilibrium expected utility differs depending on their envy parameters. If the envy parameter α becomes sufficiently large, then the newcomers who took off-the-pass-of-the-equilibrium behavior in the first period prefer to reject in the second period. Hence,

$$u_1(New, Much)_{SEP} \begin{cases} = \frac{2}{3}[-190 - 750\alpha + 0] + \frac{1}{3}[495 - 115\beta + 107 - 333\alpha], & \text{if } \alpha \leq \frac{107}{333} \\ = \frac{2}{3}[-190 - 750\alpha + 0] + \frac{1}{3}[495 - 115\beta] & , \text{otherwise} \end{cases} \quad (A.20)$$

Since $\alpha, \beta > 0$, the value of the equation (A.19) is always greater than that of the equation (A.20). Therefore, newcomers strictly prefer *Less* regardless of their inequity averseness.

From the above, separation is an equilibrium if at least either the equation (A.14) or (A.18) is satisfied. Otherwise, separation is not an equilibrium.

Next, I confirm how the inequity aversion impacts on the pooling equilibrium.

Let me begin with the analysis of the second period. Suppose every agent selects *Less* in the first period and plan D is offered in the second period.

Skilled workers' expected utility when they select *Accept* differs depending on the type of their teammate. Let a skilled worker's expected utility when he selects *Accept* and his teammate is a newcomer be $u_2(Skilled, Accept, New)$. Then, each type of agent's on-the-pass-of-the-equilibrium payoff in the second period is as follows.

$$u_2(Skilled, Accept, Skilled)_{POOL} = 628 \quad (A.21)$$

$$u_2(Skilled, Accept, New)_{POOL} = 628 - 188\beta \quad (A.22)$$

$$u_2(New, Accept, Skilled)_{POOL} = 440 - 188\alpha \quad (A.23)$$

$$u_2(New, Accept, New)_{POOL} = 440 \quad (A.24)$$

Since $\beta < 1$, the value of equation (A.22) is always strictly greater than zero. The value of the equation (A.23) becomes weakly greater than zero if,

$$\alpha \leq \frac{110}{47} \quad (A.25)$$

Based on (A.21) and (A.22), skilled workers always select *Accept* on the pass of the equilibrium. Based on (A.24), newcomers who paired with newcomers also always select *Accept* on the pass of the equilibrium. On the other hand, newcomers who paired with skilled workers select *Accept* if the equation (A.25) is satisfied, otherwise, they select *Reject*.

Before moving to the first period's analysis, I examine off-the-pass-of-the-equilibrium behavior at the second period. If skilled workers deviate and select *Much*, then both agents select *Accept* as long as the following condition (A.26) is satisfied. (A.26) is a condition when the deviator who paired with a skilled worker attains utility which is weakly greater than zero. Since the deviator's teammate always prefer *Accept* and also the deviator himself prefer *Accept* as long as he is paired with a newcomer, (A.26) is the only condition we need to care about.

$$\alpha \leq \frac{440}{333} \quad (A.26)$$

Besides, if a newcomer selects *Much* and he is paired with a skilled worker, then both team members select *Accept* if,

$$\alpha \leq \frac{107}{666} \quad (A.27)$$

If a newcomer selects *Much* and he is paired with a newcomer, then both of team members select *Accept* if,

$$\alpha \leq \frac{107}{333} \quad (A.28)$$

Next I start the first period's analysis. First, I derive conditions when skilled workers prefer *Less* in each case. Then, I also derive conditions when newcomers prefer *Less* in each case.

[Case1: $0 < \alpha \leq \frac{440}{333}$]

In this case, skilled worker's on-the-pass-of-the-equilibrium expected utility is,

$$u_1(\text{Skilled}, \text{Less})_{POOL} = \frac{2}{3}[427 + 628] + \frac{1}{3}[427 - 47\beta + 628 - 188\beta] \quad (A.29)$$

Their off-the-pass-of-the-equilibrium expected utility is,

$$u_1(Skilled, Much)_{POOL} = \frac{2}{3}[615 - 115\beta + 440 - 333\alpha] + \frac{1}{3}[615 - 235\beta + 440] \quad (A.30)$$

Comparing (A.29) and (A.30), then skilled workers always strictly prefer *Less* in this case.

$$[\text{Case2: } \frac{440}{333} < \alpha \leq \frac{110}{47}]$$

In this case, skilled worker's on-the-pass-of-the-equilibrium expected utility is the same as (A.29).

Their off-the-pass-of-the-equilibrium expected utility is,

$$u_1(Skilled, Much)_{POOL} = \frac{2}{3}[615 - 115\beta + 0] + \frac{1}{3}[615 - 235\beta + 440] \quad (A.31)$$

Comparing (A.29) and (A.31), then skilled workers always strictly prefer *Less* in this case.

$$[\text{Case3: } \frac{110}{47} < \alpha]$$

In this case, skilled worker's on-the-pass-of-the-equilibrium expected utility is,

$$u_1(Skilled, Less)_{POOL} = \frac{2}{3}[427 + 628] + \frac{1}{3}[427 - 47\beta + 0] \quad (A.32)$$

Their off-the-pass-of-the-equilibrium expected utility is the same as (A.31).

Comparing (A.32) and (A.31), then skilled workers prefer *Less* as long as the following (A.33) is satisfied.

$$\beta \geq -\frac{252}{418} \quad (A.33)$$

By the assumption, $\beta > 0$. Thus, (A.33) is always satisfied.

From the above analyses for Case 1 to Case 3, skilled workers always prefer *Less*.

Now we move on to the analysis on the newcomers' behavior.

$$[\text{Case1: } 0 < \alpha \leq \frac{107}{666}]$$

In this case, newcomer's on-the-pass-of-the-equilibrium expected utility is,

$$u_1(New, Less)_{POOL} = \frac{2}{3}[380 - 47\alpha + 440 - 188\alpha] + \frac{1}{3}[380 + 440] \quad (A.34)$$

Their off-the-pass-of-the-equilibrium expected utility is

$$u_1(New, Much)_{POOL} = \frac{2}{3}[495 - 5\alpha + 107 - 666\alpha] + \frac{1}{3}[495 - 115\beta + 107 - 333\alpha] \quad (A.35)$$

Comparing (A.34) and (A.35), then skilled workers always prefer *Less*.

[Case2: $\frac{107}{666} < \alpha \leq \frac{107}{333}$]

In this case, newcomer's on-the-pass-of-the-equilibrium expected utility is the same as (A.34).

Their off-the-pass-of-the-equilibrium expected utility is

$$u_1(New, Much)_{POOL} = \frac{2}{3}[495 - 5\alpha] + \frac{1}{3}[495 - 115\beta + 107 - 333\alpha] \quad (A.36)$$

Comparing (A.34) and (A.36), then skilled workers prefer *Less* as long as the following (A.37) is satisfied.

$$\beta \geq \frac{127}{115}\alpha - \frac{868}{115} \quad (A.37)$$

Since $\frac{107}{666} < \alpha \leq \frac{107}{333}$ and $\beta > 0$, (A.37) is always satisfied in this case.

[Case3: $\frac{107}{333} < \alpha \leq \frac{110}{47}$]

In this case, newcomer's on-the-pass-of-the-equilibrium expected utility is the same as (A.34).

Their off-the-pass-of-the-equilibrium expected utility is,

$$u_1(New, Much)_{POOL} = \frac{2}{3}[495 - 5\alpha] + \frac{1}{3}[495 - 115\beta] \quad (A.38)$$

Comparing (A.34) and (A.38), then skilled workers prefer *Less* as long as the following (A.39) is satisfied.

$$\beta \geq 4\alpha - \frac{195}{23} \quad (A.39)$$

[Case4: $\frac{110}{47} < \alpha$]

In this case, newcomer's on-the-pass-of-the-equilibrium expected utility is,

$$u_1(New, Less)_{POOL} = \frac{2}{3}[380 - 47\alpha + 0] + \frac{1}{3}[380 + 440] \quad (A.40)$$

Their off-the-pass-of-the-equilibrium expected utility is the same as (A.38).

Comparing (A.40) and (A.38), then skilled workers prefer *Less* as long as the following (A.41) is satisfied.

$$\beta \geq \frac{84}{115}\alpha - \frac{19}{23} \quad (A.41)$$

The above results are summarized in Figure 6.

A.6. LEARN with Inequity-averse Individuals

Suppose every agent reports their type truthfully in the first period. Then, as discussed in section A.5, all agents' expected utility when they select *Accept* is 440. Therefore, everyone strictly prefers *Accept* in the second period.

Skilled workers' expected utility depending on their choice in the first period is,

$$u_1(Skilled, Much) = \frac{2}{3}[560 + 440] + \frac{1}{3}[615 - 235\beta + 440] \quad (A.42)$$

$$u_1(Skilled, Less) = \frac{2}{3}[500 - 115\alpha + 440] + \frac{1}{3}[427 - 47\beta + 628] \quad (A.43)$$

Since $\alpha \geq \beta$, the value of the equation (A.42) is always greater than that of the equation (A.43). Therefore, skilled workers strictly prefer *Much* regardless of their inequity averseness.

Similarly, newcomers' expected utility depending on their decision in the first period is,

$$u_1(New, Much) = \frac{2}{3}[-190 - 750\alpha + 440] + \frac{1}{3}[495 - 115\beta + 0] \quad (A.44)$$

$$u_1(New, Less) = \frac{2}{3}[380 - 235\alpha + 440] + \frac{1}{3}[380 + 440] \quad (A.45)$$

Since $\alpha, \beta > 0$, newcomers strictly prefer *Less* regardless of their inequity averseness.

B. An Experimental Procedure for Measurement of Inequity Aversion

I measure the inequity aversion parameters by the BDM mechanism (Becker et al., 1964). In this experiment, participants are randomly matched as a pair. This experiment consists of two parts. The first part is for measurement of α , and the latter one is for measurement of β .

In the first part, each participant answers the following 11 binary-choice problems as shown in Figure 11.

Figure 11: Choice Problems for Measuring the Preference Parameter of Envy

Period 1 / 1 Remaining Time [sec]: 58

Plan A-1:
You get ¥150, Partner gets ¥250

Plan A-2:
You get ¥X, Partner gets ¥X

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥50. Partner gets ¥50

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥60. Partner gets ¥60

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥70. Partner gets ¥70

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥80. Partner gets ¥80

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥90. Partner gets ¥90

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥100. Partner gets ¥100

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥110. Partner gets ¥110

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥120. Partner gets ¥120

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥130. Partner gets ¥130

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥140. Partner gets ¥140

A-1: You get ¥150. Partner gets ¥250 A-2: You get ¥150. Partner gets ¥150

OK

I measure α based on the following equation.

$$\alpha = \frac{150 - \text{SwitchingPoint}_\alpha}{100} \quad (B.1)$$

$\text{SwitchingPoint}_\alpha$ is identified as the minimum value where participants select the right-hand-side alternative. For participants who have more than two kinks in their choice behavior, I don't define α and let it as a missing value.

In the latter part, I measure β using a similar procedure. Figure 12 shows 11 binary-choice problems in this part. β is measured following the equation (B.2). The definition of $\text{SwitchingPoint}_\beta$ is similar to that of $\text{SwitchingPoint}_\alpha$.

$$\beta = \frac{250 - \text{SwitchingPoint}_\beta}{100} \quad (B.2)$$

Figure 12: Choice Problems for Measuring the Preference Parameter of Guilt

Period
1 / 1

Remaining Time
[sec]: 54

Plan B-1:
You get ¥250, Partner gets ¥150

Plan B-2:
You get ¥Y, Partner gets ¥Y

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥150. Partner gets ¥150

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥160. Partner gets ¥160

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥170. Partner gets ¥170

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥180. Partner gets ¥180

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥190. Partner gets ¥190

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥200. Partner gets ¥200

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥210. Partner gets ¥210

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥220. Partner gets ¥220

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥230. Partner gets ¥230

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥240. Partner gets ¥240

B-1: You get ¥250. Partner gets ¥150

B-2: You get ¥250. Partner gets ¥250

OK

When every participant finishes answering the above choice problems, one out of 22 problems is randomly selected. Also, within each pair, either one participant is randomly selected. Based on the selected participant's answer at the selected problem, each participants' rewards from this task are determined.

C. Original Experimental Instructions (Japanese)

This experiment was conducted in Japanese. If you want to see the English version, please refer to Appendix D.

C.1. Instructions of the Team-production Task in *ONE*

インストラクション

※実験中は、実験者への質問を除いて、他の人とコミュニケーションを取らないでください。これが破られた場合には、その時点で実験を中止することがあります。

※また、本実験は皆さんの目の前にある PC を用いて行いますが、指示された以外の操作をしないでください。そのような人を見つけた場合も、実験を中止することがあります。

最初に、以下のものが全てそろっていることを確認してください。足りないものがある場合には、手を挙げて実験者に知らせてください。

- インストラクション（本紙です）
- 第 1 部用記録用紙
- 計画（別紙 1）
- 最終結果記録用紙
- 筆記用具

これから行う実験の構成

実験は第 1 部と第 2 部の二つのパートから構成されています。第 1 部と第 2 部は完全に独立した別の実験です。すなわち、第 1 部でどのような意思決定を行ったかが、第 2 部の結果に影響することはありませんし、同様に、第 2 部でどのような意思決定を行ったかが、第 1 部の結果に影響することはありません。

いずれのパートにおいても、実験手続きの説明をよく読んだうえで、意思決定を行ってください。また、実験内容について説明を行った後、皆さんが説明を正しく理解しているかどうかを確認するための理解度確認クイズを行います。全員がこの理解度確認クイズに正解できるまで、本番の実験を開始することができません。

皆さんがこの実験から得る実験謝金は、第 1 部、第 2 部のそれぞれで行った意思決定の結果に応じて独立に決定される額を足し合わせたものに、参加謝金 800 円を加えた額となります。実験謝金の詳しい決まり方は、第 1 部と第 2 部のそれぞれで異なり、それぞれのパートが始まる前に説明します。

第 1 部の説明

実験で想定する状況の概要

この実験では、共同して製品 α を生産する二人の従業員から成る生産チームと、そのチームの生産計画を決める経営者がいる状況を想定します。皆さんは従業員の役割をします。経営者の決定は PC がルールに従って行います。ルールを含めて、詳細は後ほど画面操作とともに説明します。

この生産チームは、図 1 のような生産活動を一期間行います。

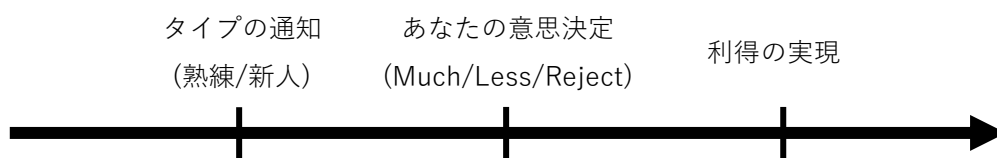


図 1：生産活動のタイムライン

従業員には、この生産活動に熟練している熟練者と、そうでない新人がいます。

皆さんのうち、2/3 の人に熟練者、1/3 の人に新人、の役割が割り当てられます。なお、あなたのチームメイトが熟練者と新人のいずれであるかは分かりません。同様に、あなたのチームメイトから見て、あなたが熟練者と新人のいずれであるかは分かりません。

生産活動が始まる前に、あなたの役割が熟練者と新人のいずれであるか通知します。

初めに経営者（PC）は、二人の従業員にそれぞれどのくらい生産できそうかという見込みを尋ねます。そして、この二人の回答結果に基づき、チームの生産量および各従業員への報酬額の計画を決定します。

この生産および報酬の計画が決定されたならば、計画通りに従業員たちは生産活動を行います。生産活動の終わりに経営者（PC）は、各従業員に対して計画に従って報酬を支払います。従業員の利得は、「利得 = 獲得した報酬 - 生産活動に伴うコスト」として決まります。なお、生産活動に伴うコストは次のような関係にあります。生産量が多いほど、コストは大きくなります。また、熟練者は新人に比べて、同じ生産活動を行った場合のコストが小さくなります。これで生産活動は終わりです。

なお、この実験では、以上の生産活動を 20 回繰り返して行います。その際、あなたの役割、すなわちあなたが熟練者と新人のいずれであるか、は一連の活動が終わるごとに毎回再割り当てされます。再割り当てする際は、最初と同様に、2/3 の確率で熟練者、1/3 の確率で新人、の役割を割り当てます。

また、誰と誰がチームとなるかは、一連の活動が終わるごとに無作為に再決定します。

以下では、具体的なルールと画面操作について、時系列順に説明します。

タイプの通知

まず、あなたは熟練者と新人のうちいずれの役割を割り当てられたのか、が図2のような画面で通知されます。



図2：タイプの通知画面（あなたが熟練者の場合）

あなたの意思決定

あなたとチームメイトの従業員は、それぞれどれくらい生産できそうかという見込みを同時に回答します。ここでは、*Much*、*Less*、*Reject*、の三択で回答します。

ここで *Much* と *Less* はそれぞれ、沢山の生産量、少しの生産量、を意味しています。すなわち、*Much* と答えたならば、*Less* と答えた場合に比べて沢山の仕事を行うことを意味しています。一方 *Reject* とは、全ての計画を拒否してこの職場を去ることを意味しています。この生産チームは従業員が二人揃わないと生産活動が行えないため、一人でも *Reject* を選択した場合には、生産活動を行わず、全ての人の利得が0となります。

回答は、図3の意思決定画面の下側にある、対応する選択肢のボタンをクリックして入力します。入力が終わると、OK ボタンをクリックして次へ進みます。



図3：意思決定画面の例（あなたが熟練者の場合）

あなたとチームメイトの意思決定に応じた利得の決まり方は、図3の意思決定画面の上側に表示されている表が示しています。この表は、あなたが熟練者の場合には別紙1の表(熟練)、あなたが新人の場合には表(新人)、と同じなので、別紙1を参照しながら以下の説明を聞いてください。

以下では、あなたが熟練者の場合を例に説明します。別紙1にある表(熟練)を見てください。あなたが *Much* を選択し、チームメイトが *Less* を選択したならば、あなたが受取る利得は 615 です。チームメイトの利得は、チームメイトが熟練者と新人のいずれであるかによって異なります。チームメイトが熟練者ならば 500、新人ならば 380、がチームメイトの利得となります。皆さんの利得額は、あなたとチームメイトの意思決定、また両者が熟練者と新人のいずれであるか、に応じて異なります。後で理解するための時間を設けるので、よく確認してください。

なお、別紙1は実験中に適宜参照して構いません。

あなたが第1部の実験から得る実験謝金額の決まり方

あなたが第1部の実験から得る謝金の額は次のように定まります。

まず、20回の意思決定のうちどれか一回が無作為に選択されます。なお、どの回が選択されたのかは、第1部の最後にお伝えします。

選択された回であなたが得た利得が、第1部の実験からあなたが得る実験謝金額となります。なお、利得1単位は1円に相当します。例えば、選ばれた回での利得が 615 であった場合、あなたが第1部から得る実験謝金額は 615 円です。

以上が第一部の実験の説明です。これから 3 分間時間をとりますので、各自説明をよく読んで理解してください。質問がある人は、静かに挙手をしてください。

C.2. Instructions of the Team-production Task in *NOLEARN*

インストラクション

※実験中は、実験者への質問を除いて、他の人とコミュニケーションを取らないでください。これが破られた場合には、その時点で実験を中止することがあります。

※また、本実験は皆さんの目の前にある PC を用いて行いますが、指示された以外の操作をしないでください。そのような人を見つけた場合も、実験を中止することがあります。

最初に、以下のものが全てそろっていることを確認してください。足りないものがある場合には、手を挙げて実験者に知らせてください。

- インストラクション（本紙です）
- 第 1 部用記録用紙
- 第一期および第二期の計画（別紙 1）
- 最終結果記録用紙
- 筆記用具

実験の構成

実験は第 1 部と第 2 部の二つのパートから構成されています。第 1 部と第 2 部は完全に独立した別の実験です。すなわち、第 1 部でどのような意思決定を行ったかが、第 2 部の結果に影響することはありませんし、同様に、第 2 部でどのような意思決定を行ったかが、第 1 部の結果に影響することはありません。

いずれのパートにおいても、実験手続きの説明をよく読んだうえで、意思決定を行ってください。また、実験内容について説明を行った後、皆さんが説明を正しく理解しているかどうかを確認するための理解度確認クイズを行います。全員がこの理解度確認クイズに正解できるまで、本番の実験を開始することができません。

皆さんがこの実験から得る実験謝金は、第 1 部、第 2 部のそれぞれで行った意思決定の結果に応じて独立に決定される額を足し合わせたものに、参加謝金 800 円を加えた額となります。実験謝金の詳しい決まり方は、第 1 部と第 2 部のそれぞれで異なり、それぞれのパートが始まる前に説明します。

第 1 部の説明

実験で想定する状況の概要

この実験では、共同して製品 α を生産する二人の従業員から成る生産チームと、そのチームの生産計画を決める経営者がいる状況を想定します。皆さんは従業員の役割をします。

経営者の決定は PC がルールに従って行います。ルールを含めて、詳細は後ほど画面操作とともに説明します。

この生産チームは、図 1 のように、第一期と第二期の二期間にわたって生産活動を行います。

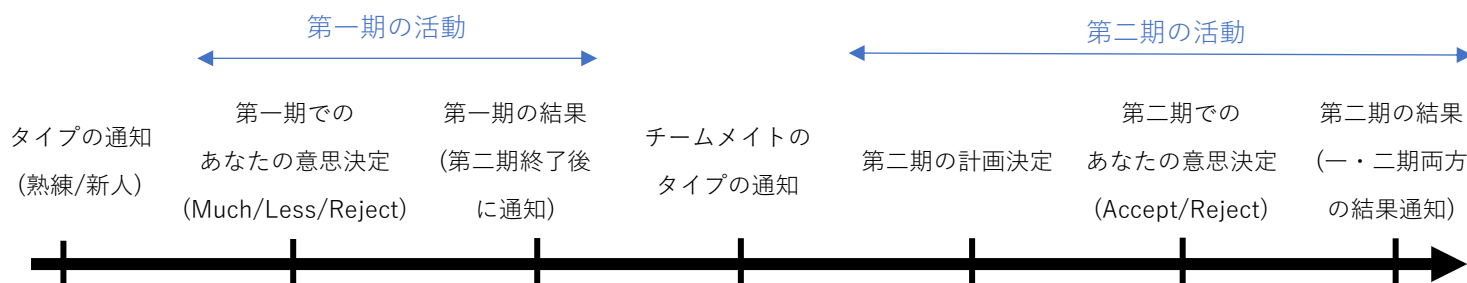


図 1：二期間の活動のタイムライン

従業員には、この生産活動に熟練している熟練者と、そうでない新人がいます。

皆さんのうち、2/3 の人に熟練者、1/3 の人に新人、の役割が割り当てられます。なお、あなたのチームメイトが熟練者と新人のいずれであるかは分かりません。同様に、あなたのチームメイトから見て、あなたが熟練者と新人のいずれであるかは分かりません。

第一期が始まる前に、あなたの役割が熟練者と新人のいずれであるか通知します。

第一期の初めに経営者 (PC) は、二人の従業員にそれぞれ第一期にどのくらい生産できそうかという見込みを尋ねます。そして、この二人の回答結果に基づき、第一期のチームの生産量および各従業員への報酬額の計画を決定します。

この生産および報酬の計画が決定されたならば、計画通りに従業員たちは第一期の生産活動を行います。第一期の終わりに経営者 (PC) は、各従業員に対して計画に従って第一期の報酬を支払います。従業員の第一期の利得は、「第一期の利得 = 第一期に獲得した報酬 - 第一期の生産活動に伴うコスト」として決まります。なお、生産活動に伴うコストは次のような関係にあります。生産量が多いほど、コストは大きくなります。また、熟練者は新人に比べて、同じ生産活動を行った場合のコストが小さくなります。ここまでの第一期の活動です。

第一期から第二期に移る間に、第一期にチームとして共に生産活動を行った結果、あなたはチームメイトの能力水準 (熟練者と新人のいずれか) を知ることができます。

第二期に移ると、まず、第一期の従業員の回答結果に基づき、経営者 (PC) が第二期の生産および報酬の計画を決定します。

計画が決定されたのち、各従業員は、その計画通りに生産活動を行って計画に記された通りの報酬を受け取るか、計画を拒否してこの職場を去るか、を決定します。二人の従業員の意思決定に応じて、第二期の結果が定まります。これで第二期の活動が終わります。

なお、この実験では、以上の二期間の活動を 20 回繰り返して行います。その際、あなたの役割、すなわちあなたが熟練者と新人のいずれであるか、は二期間の一連の活動が終わ

るごとに毎回再割り当てされます。再割り当てする際は、最初と同様に、2/3 の確率で熟練者、1/3 の確率で新人、の役割を割り当てます。

また、誰と誰がチームとなるかは、二期間の活動が終わるごとに無作為に再決定します。

以下では、具体的なルールと画面操作について、時系列順に説明します。

タイプの通知

まず、あなたは熟練者と新人のうちいずれの役割を割り当てられたのか、が図2のような画面で通知されます。

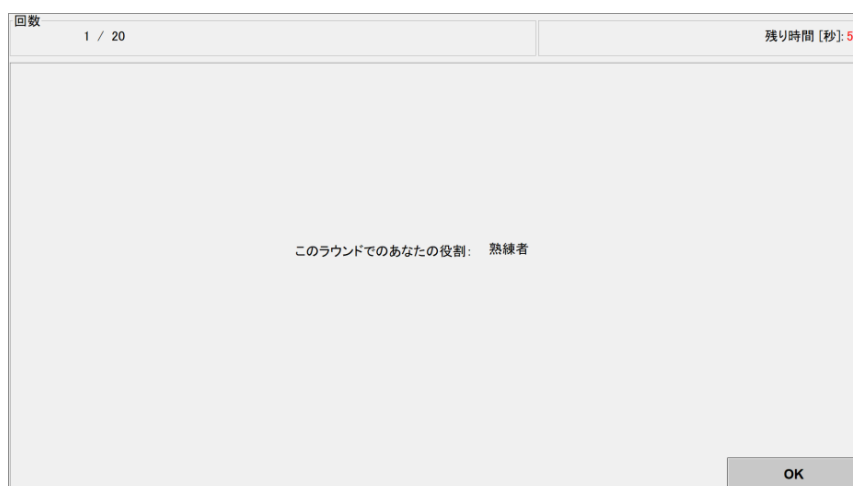


図2：タイプの通知画面（あなたが熟練者の場合）

第一期でのあなたの意思決定

あなたとチームメイトの従業員は、それぞれ第一期にどれくらい生産できそうかという見込みを同時に回答します。ここでは、*Much*、*Less*、*Reject*、の三択で回答します。

ここで *Much* と *Less* はそれぞれ、沢山の生産量、少しの生産量、を意味しています。すなわち、*Much* と答えたならば、*Less* と答えた場合に比べて沢山の仕事を行うことを意味しています。一方 *Reject* とは、全ての計画を拒否してこの職場を去ることを意味しています。この生産チームは従業員が二人揃わないと生産活動が行えないため、一人でも *Reject* を選択した場合には、生産活動を行わず、全ての人の利得が 0 となります。なお、第一期に生産活動が行われなかった場合、第二期に移ることなく終了します。

回答は、図3の意思決定画面の下側にある、対応する選択肢のボタンをクリックして入力します。入力が終わると、OK ボタンをクリックして次へ進みます。

回数 1 / 20 残り時間 [秒]: 86

あなたの選択	チームメイトの選択	あなたの利得	チームメイトの利得 (熟練者の場合)	チームメイトの利得 (新人の場合)
Much	Much	560	560	-190
	Less	615	500	380
	Reject	0	0	0
Less	Much	500	615	495
	Less	427	427	380
	Reject	0	0	0
Reject	-	0	0	0

このラウンドでのあなたの役割: 熟練者

第一期のあなたの行動を選択してください

☐ Much
☐ Less
☐ Reject

OK

図 3：第一期の意思決定画面の例（あなたが熟練者の場合）

あなたとチームメイトの意思決定に応じた利得の決まり方は、図 3 の意思決定画面の上側に表示されている表が示しています。この表は、あなたが熟練者の場合には別紙 1 の表(熟練 1)、あなたが新人の場合には表(新人 1)、と同じなので、別紙 1 を参照しながら以下の説明を聞いてください。

以下では、あなたが熟練者の場合を例に説明します。別紙 1 左上にある表(熟練 1)を見てください。第一期にあなたが *Much* を選択し、チームメイトが *Less* を選択したならば、あなたが第一期に受取る利得は 615 です。チームメイトの利得は、チームメイトが熟練者と新人のいずれであるかによって異なります。チームメイトが熟練者ならば 500、新人ならば 380、がチームメイトの第一期の利得となります。皆さんの利得額は、あなたとチームメイトの意思決定、また両者が熟練者と新人のいずれであるか、に応じて異なります。後で理解するための時間を設けるので、よく確認してください。

なお、第一期の結果は、第二期が終わった時点で皆さんにお知らせします。また、別紙 1 は実験中に適宜参照して構いません。

チームメイトのタイプの通知

第一期から第二期の間に、あなたはチームメイトが熟練者と新人のいずれかを知ります。あなたのチームメイトのタイプは図 4 のような画面で通知されます。



図4：あなたとチームメイトが共に熟練者である場合の通知画面

第二期の計画決定

第一期の従業員の回答結果に基づき、第二期の生産量、各従業員の第二期の報酬額、の計画が決定します。第一期での回答結果と第二期の計画の選ばれ方がどのように対応しているかは、表1に示しています。

先程と同様に、あなたが熟練者の場合を例に説明します。第一期にあなたが *Much* を選択し、チームメイトが *Less* を選択したならば、計画Bが第二期の計画として選択されます。

あなたの選択（第一期）	チームメイトの選択（第一期）	第二期の計画
<i>Much</i>	<i>Much</i>	A
<i>Much</i>	<i>Less</i>	B
<i>Less</i>	<i>Much</i>	C
<i>Less</i>	<i>Less</i>	D

表1：第一期の意思決定と第二期の計画の対応関係

どの計画が第二期の計画として選ばれたのかは、図5のような画面で通知されます。

回数

1 / 20

残り時間 [秒]: 46

このラウンドでのあなたの役割: 熟練者

このラウンドでのチームメイトの役割: 熟練者

あなたとチームメイトの第一期での選択の結果、第二期の生産計画は下記のものに決まりました

OK

第二期 の計画	あなたと チームメイトの 選択	あなたの利得	チームメイトの利得
B	Both Accept	440	773
	Others	0	0

図5：第二期の計画を通知する画面の例（あなたとチームメイトが共に熟練者の場合）

計画 A から D における具体的な利得額は、別紙 1 の表(熟練 2)、および表(新人 2)に示しています。これらの表の読み方は、次節の第二期でのあなたの意思決定で詳しく説明します。

第二期でのあなたの意思決定

図 5 の画面を確認したのち、OK ボタンを押すと図 6 のような画面が表示されます。意思決定画面の上側には、先ほど通知された第二期の計画と同じものが表示されています。

あなたの選択	チームメイトの選択	あなたの利得	チームメイトの利得
Accept	Accept	440	773
	Reject	0	0
Reject	-	0	0

このラウンドでのあなたの役割: 熟練者

第二期のあなたの行動を選択してください ☐ Accept ☐ Reject

OK

図 6：第二期の意思決定画面の例（あなたとチームメイトが共に熟練者の場合）

ここであなたとチームメイトは同時に次の二つの選択肢から一つを選びます。一つ目の選択肢 *Accept* は、画面に表示された第二期の計画を受け入れ、その通りに生産活動を行い、計画に示された通りの利得を受け取ることを希望するというものです。二つ目の選択肢 *Reject* は、画面に表示された計画を拒否して 0 円を受け取り、生産活動を行わずにこの職場を去るというものです。このあなたとチームメイトの選択結果の組に応じて、表 2 の通りに第二期の結果が定まります。

表 2 の見方を説明します。あなたとチームメイトの両方が *Accept* を選んだならば、第二期には計画通りに生産活動を行います。一方、あなたとチームメイトの少なくとも一方が *Reject* を選んだ場合には、第二期には生産活動を行いません。

あなたの選択（第二期）	チームメイトの選択（第二期）	第二期の結果
<i>Accept</i>	<i>Accept</i>	計画通りの生産活動を行う
<i>Accept</i>	<i>Reject</i>	生産活動を行わない
<i>Reject</i>	<i>Accept</i>	
<i>Reject</i>	<i>Reject</i>	

表 2：第二期の意思決定と第二期の結果の対応関係

第二期の利得の決まり方を具体例で説明します。これまでの例と同様に、あなたとチームメイトが共に熟練者である場合に、第一期にあなたが *Much*、チームメイトが *Less* を選択し、計画 B が第二期の計画として選ばれている場合を考えます。このとき、あなたとチームメイトの両者が *Accept* を選んだ場合、第二期の利得は、あなたは 440、チームメイトは 773 となります。一方、あなたとチームメイトの少なくとも一方が *Reject* を選択した場合、あなた、チームメイト、ともに第二期の利得は 0 となります。

あなたが第 1 部の実験から得る実験謝金額の決まり方

あなたが第 1 部の実験から得る謝金の額は次のように定まります。

まず、20 回の意思決定のうちどれか一回が無作為に選択されます。なお、どの回が選択されたのかは、第 1 部の最後にお伝えします。

選択された回であなたが得た第一期の利得と第二期の利得の合計額が、第 1 部の実験からあなたが得る実験謝金額となります。なお、利得 1 単位は 1 円に相当します。例えば、選ばれた回での第一期の利得が 615、第二期の利得が 440 であった場合、あなたが第 1 部から得る実験謝金額は、 $615 \text{ 円} + 440 \text{ 円} = 1055 \text{ 円}$ です。

以上が第一部の実験の説明です。これから 3 分間時間をとりますので、各自説明をよく読んで理解してください。質問がある人は、静かに挙手をしてください。

C.3. Instructions of the Team-production Task in *LEARN*

インストラクション

※実験中は、実験者への質問を除いて、他の人とコミュニケーションを取らないでください。これが破られた場合には、その時点で実験を中止することがあります。

※また、本実験は皆さんの目の前にある PC を用いて行いますが、指示された以外の操作をしないでください。そのような人を見つけた場合も、実験を中止することがあります。

最初に、以下のものが全てそろっていることを確認してください。足りないものがある場合には、手を挙げて実験者に知らせてください。

- インストラクション（本紙です）
- 第 1 部用記録用紙
- 第一期および第二期の計画（別紙 1）
- 最終結果記録用紙
- 筆記用具

実験の構成

実験は第 1 部と第 2 部の二つのパートから構成されています。第 1 部と第 2 部は完全に独立した別の実験です。すなわち、第 1 部でどのような意思決定を行ったかが、第 2 部の結果に影響することはありませんし、同様に、第 2 部でどのような意思決定を行ったかが、第 1 部の結果に影響することはありません。

いずれのパートにおいても、実験手続きの説明をよく読んだうえで、意思決定を行ってください。また、実験内容について説明を行った後、皆さんが説明を正しく理解しているかどうかを確認するための理解度確認クイズを行います。全員がこの理解度確認クイズに正解できるまで、本番の実験を開始することができません。

皆さんがこの実験から得る実験謝金は、第 1 部、第 2 部のそれぞれで行った意思決定の結果に応じて独立に決定される額を足し合わせたものに、参加謝金 800 円を加えた額となります。実験謝金の詳しい決まり方は、第 1 部と第 2 部のそれぞれで異なり、それぞれのパートが始まる前に説明します。

第 1 部の説明

実験で想定する状況の概要

この実験では、共同して製品 α を生産する二人の従業員から成る生産チームと、そのチームの生産計画を決める経営者がいる状況を想定します。皆さんは従業員の役割をします。

経営者の決定はPCがルールに従って行います。ルールを含めて、詳細は後ほど画面操作とともに説明します。

この生産チームは、図1のように、第一期と第二期の二期間にわたって生産活動を行います。

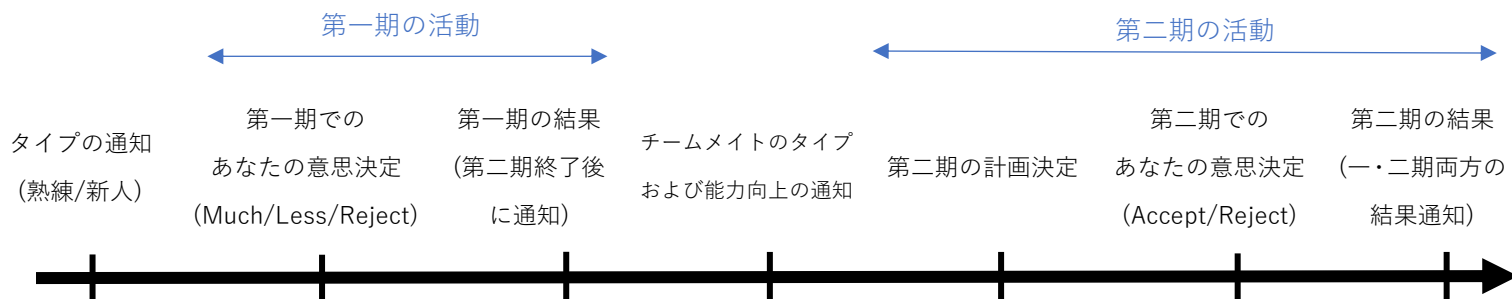


図1：二期間の活動のタイムライン

従業員には、この生産活動に熟練している熟練者と、そうでない新人がいます。

皆さんのうち、2/3の人に熟練者、1/3の人に新人、の役割が割り当てられます。なお、あなたのチームメイトが熟練者と新人のいずれであるかは分かりません。同様に、あなたのチームメイトから見て、あなたが熟練者と新人のいずれであるかは分かりません。

第一期が始まる前に、あなたの役割が熟練者と新人のいずれであるか通知します。

第一期の初めに経営者(PC)は、二人の従業員にそれぞれ第一期にどのくらい生産できそうかという見込みを尋ねます。そして、この二人の回答結果に基づき、第一期のチームの生産量および各従業員への報酬額の計画を決定します。

この生産および報酬の計画が決定されたならば、計画通りに従業員たちは第一期の生産活動を行います。第一期の終わりに経営者(PC)は、各従業員に対して計画に従って第一期の報酬を支払います。従業員の第一期の利得は、「第一期の利得 = 第一期に獲得した報酬 - 第一期の生産活動に伴うコスト」として決まります。なお、生産活動に伴うコストは次のような関係にあります。生産量が多いほど、コストは大きくなります。また、熟練者は新人に比べて、同じ生産活動を行った場合のコストが小さくなります。ここまでの第一期の活動です。

第一期から第二期に移る間に、次の二つの事が起こります。第一に、第一期にチームとして共に生産活動を行った結果、あなたはチームメイトの能力水準(熟練者と新人のいずれか)を知ることができます。第二に、チームメイトが熟練者である新人は、第一期に熟練者と共に仕事を行うなかで得た学びによって、能力が向上します。

第二期に移ると、まず、第一期の従業員の回答結果に基づき、経営者(PC)が第二期の生産および報酬の計画を決定します。

計画が決定されたのち、各従業員は、その計画通りに生産活動を行って計画に記された通りの報酬を受け取るか、計画を拒否してこの職場を去るか、を決定します。二人の従業員の意思決定に応じて、第二期の結果が定まります。これで第二期の活動が終わります。

なお、この実験では、以上の二期間の活動を 20 回繰り返して行います。その際、あなたの役割、すなわちあなたが熟練者と新人のいずれであるか、は二期間の一連の活動が終わるごとに毎回再割り当てされます。再割り当てする際は、最初と同様に、2/3 の確率で熟練者、1/3 の確率で新人、の役割を割り当てます。

また、誰と誰がチームとなるかは、二期間の活動が終わるごとに無作為に再決定します。

以下では、具体的なルールと画面操作について、時系列順に説明します。

タイプの通知

まず、あなたは熟練者と新人のうちいずれの役割を割り当てられたのか、が図 2 のような画面で通知されます。

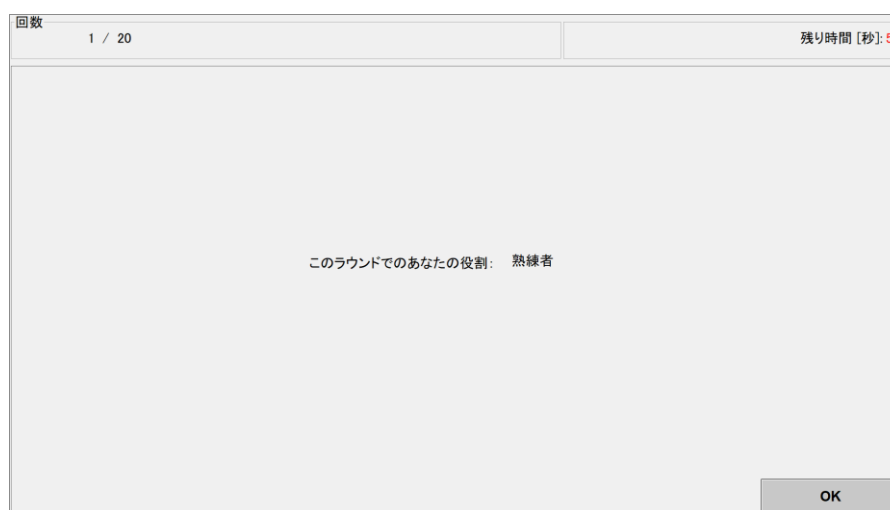


図 2：タイプの通知画面（あなたが熟練者の場合）

第一期でのあなたの意思決定

あなたとチームメイトの従業員は、それぞれ第一期にどれくらい生産できそうかという見込みを同時に回答します。ここでは、*Much*、*Less*、*Reject*、の三択で回答します。

ここで *Much* と *Less* はそれぞれ、沢山の生産量、少しの生産量、を意味しています。すなわち、*Much* と答えたならば、*Less* と答えた場合に比べて沢山の仕事を行うことを意味しています。一方 *Reject* とは、全ての計画を拒否してこの職場を去ることを意味しています。この生産チームは従業員が二人揃わないと生産活動が行えないため、一人でも *Reject* を選択した場合には、生産活動を行わず、全ての人の利得が 0 となります。なお、第一期に生産活動が行われなかった場合、第二期に移ることなく終了します。

回答は、図 3 の意思決定画面の下側にある、対応する選択肢のボタンをクリックして入力します。入力が終わると、OK ボタンをクリックして次へ進みます。

回数
1 / 20
残り時間 [秒]: 86

あなたの選択	チームメイトの選択	あなたの利得	チームメイトの利得 (熟練者の場合)	チームメイトの利得 (新人の場合)
Much	Much	560	560	-190
	Less	615	500	380
	Reject	0	0	0
Less	Much	500	615	495
	Less	427	427	380
	Reject	0	0	0
Reject	-	0	0	0

このラウンドでのあなたの役割: 熟練者
第一期のあなたの行動を選択してください

☐ Much
☐ Less
☐ Reject

OK

図 3：第一期の意思決定画面の例（あなたが熟練者の場合）

あなたとチームメイトの意思決定に応じた利得の決まり方は、図 3 の意思決定画面の上側に表示されている表が示しています。この表は、あなたが熟練者の場合には別紙 1 の表(熟練 1)、あなたが新人の場合には表(新人 1)、と同じなので、別紙 1 を参照しながら以下の説明を聞いてください。

以下では、あなたが熟練者の場合を例に説明します。別紙 1 左上にある表(熟練 1)を見てください。第一期にあなたが *Much* を選択し、チームメイトが *Less* を選択したならば、あなたが第一期に受取る利得は 615 です。チームメイトの利得は、チームメイトが熟練者と新人のいずれであるかによって異なります。チームメイトが熟練者ならば 500、新人ならば 380、がチームメイトの第一期の利得となります。皆さんの利得額は、あなたとチームメイトの意思決定、また両者が熟練者と新人のいずれであるか、に応じて異なります。後で理解するための時間を設けるので、よく確認してください。

なお、第一期の結果は、第二期が終わった時点で皆さんにお知らせします。また、別紙 1 は実験中に適宜参照して構いません。

チームメイトのタイプおよび能力向上の通知

第一期から第二期の間に、あなたはチームメイトが熟練者と新人のいずれかを知ります。

加えて、チームメイトが熟練者である新人は、第一期に熟練者と共に働くなかで得た学びによって、能力水準が向上します。向上後の新人の能力水準は、熟練者と同じレベルです。なお、チームメイトも新人である場合、新人の能力向上は起きません。加えて、熟練者の能力は既に十分高まっているため、誰とチームになろうとも熟練者の能力向上は起きません。

チームメイトのタイプおよび能力向上は、次の図 4・5・6 のような画面で通知されます。

回数	残り時間 [秒]: 6
1 / 20	
このラウンドでのあなたの役割: 新人 あなたのチームメイトの役割は下記のものと分かりました	
このラウンドでのチームメイトの役割: 熟練者 チームメイトが熟練者のため、あなたの能力は向上しました あなたの能力は熟練者と同じ水準になりました	
OK	

図 4：あなたは新人、チームメイトは熟練者、の場合

回数	残り時間 [秒]: 3
1 / 20	
このラウンドでのあなたの役割: 新人 チームメイトの役割と能力向上は下記の通りだと分かりました	
このラウンドでのチームメイトの役割: 新人 あなたとチームメイトの双方が新人のため、能力向上は起きませんでした あなたとチームメイトの能力は第一期の水準のまま変化ありません	
OK	

図 5：あなたは新人、チームメイトは新人、の場合

回数	残り時間 [秒]: 20
1 / 20	
このラウンドでのあなたの役割: 熟練者 チームメイトの役割と能力向上は下記の通りだと分かりました	
このラウンドでのチームメイトの役割: 熟練者 あなたもチームメイトも既に能力の高い熟練者であるため、更なる能力向上は起きませんでした あなたとチームメイトの能力は第一期の水準のまま変化ありません	
OK	

図 6：あなたは熟練者、チームメイトは熟練者、の場合

第二期の計画決定

第一期の従業員の回答結果に基づき、第二期の生産量、各従業員の第二期の報酬額、の計画が決定します。第一期での回答結果と第二期の計画の選ばれ方がどのように対応しているかは、表1に示しています。

先程と同様に、あなたが熟練者の場合を例に説明します。第一期にあなたが *Much* を選択し、チームメイトが *Less* を選択したならば、計画 X が第二期の計画として選択されます。

あなたの選択 (第一期)	チームメイトの選択 (第一期)	第二期の計画
<i>Much</i>	<i>Much</i>	X
<i>Much</i>	<i>Less</i>	
<i>Less</i>	<i>Much</i>	
<i>Less</i>	<i>Less</i>	Y

表1：第一期の意思決定と第二期の計画の対応関係

どの計画が第二期の計画として選ばれたのかは、図7のような画面で通知されます。

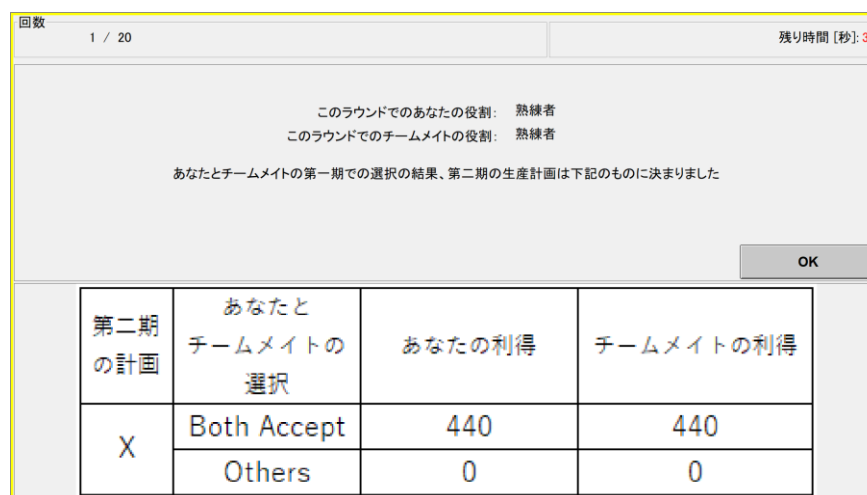


図7：第二期の計画を通知する画面の例（あなたとチームメイトが共に熟練者の場合）

計画 X および Y における具体的な利得額は、別紙1の表(熟練2)および表(新人2)に示しています。これらの表の読み方は、次節の第二期でのあなたの意思決定で詳しく説明します。

第二期でのあなたの意思決定

図7の画面を確認したのち、OK ボタンを押すと図8のような画面が表示されます。意思決定画面の上側には、先ほど通知された第二期の計画と同じものが表示されています。

あなたの選択	チームメイトの選択	あなたの利得	チームメイトの利得
Accept	Accept	440	440
	Reject	0	0
Reject	-	0	0

このラウンドでのあなたの役割: 熟練者

第二期のあなたの行動を選択してください ☐ Accept ☐ Reject

OK

図 8：第二期の意思決定画面の例（あなたとチームメイトが共に熟練者の場合）

ここであなたとチームメイトは同時に次の二つの選択肢から一つを選びます。一つ目の選択肢 *Accept* は、画面に表示された第二期の計画を受け入れ、その通りに生産活動を行い、計画に示された通りの利得を受け取ることを希望するというものです。二つ目の選択肢 *Reject* は、画面に表示された計画を拒否して 0 円を受け取り、生産活動を行わずにこの職場を去るというものです。このあなたとチームメイトの選択結果の組に応じて、表 2 の通りに第二期の結果が定まります。

表 2 の見方を説明します。あなたとチームメイトの両方が *Accept* を選んだならば、第二期には計画通りに生産活動を行います。一方、あなたとチームメイトの少なくとも一方が *Reject* を選んだ場合には、第二期には生産活動を行いません。

あなたの選択 (第二期)	チームメイトの選択 (第二期)	第二期の結果
<i>Accept</i>	<i>Accept</i>	計画通りの生産活動を行う
<i>Accept</i>	<i>Reject</i>	生産活動を行わない
<i>Reject</i>	<i>Accept</i>	
<i>Reject</i>	<i>Reject</i>	

表 2：第二期の意思決定と第二期の結果の対応関係

第二期の利得の決まり方を具体例で説明します。これまでの例と同様に、あなたとチームメイトが共に熟練者である場合に、第一期にあなたが *Much*、チームメイトが *Less* を選択し、計画 X が第二期の計画として選ばれている場合を考えます。このとき、あなたとチームメイトの両者が *Accept* を選んだ場合、第二期の利得は、あなたは 440、チームメイトは 440 となります。一方、あなたとチームメイトの少なくとも一方が *Reject* を選択した場合、あなた、チームメイト、ともに第二期の利得は 0 となります。

あなたが第1部の実験から得る実験謝金額の決まり方

あなたが第1部の実験から得る謝金の額は次のように定まります。

まず、20回の意思決定のうちどれか一回が無作為に選択されます。なお、どの回が選択されたのかは、第1部の最後にお伝えします。

選択された回であなたが得た第一期の利得と第二期の利得の合計額が、第1部の実験からあなたが得る実験謝金額となります。なお、利得1単位は1円に相当します。例えば、選ばれた回での第一期の利得が615、第二期の利得が440であった場合、あなたが第1部から得る実験謝金額は、 $615\text{円} + 440\text{円} = 1055\text{円}$ です。

以上が第一部の実験の説明です。これから3分間時間をとりますので、各自説明をよく読んで理解してください。質問がある人は、静かに挙手をしてください。

C.4. Instructions of the Task for Measuring Inequity Aversion

第 2 部の説明

実験で想定する状況の概要

皆さんは、あなたと相手の二人組となり、それぞれが受け取るお金の額を決定する問題に取り組みます。これから、二人の受取額について皆さんの意見を尋ねます。皆さんが意見を述べた後、二人のうち無作為に一人が選ばれ、選ばれた人の意見の通りに支払いが行われます。

これから、二つの問い（問 A および問 B）が表示されます。問 A と問 B は形式が似ていますが、受取額の案の内容が異なりますので、注意して回答してください。以下では、問 A、問 B、の順に詳細な手順を説明します。

問 A の手順

問 A では、図 1 のような画面が表示されます。意思決定画面の左側には、「あなたと相手の受取額の案 A-1：あなたに 150 円、相手に 250 円」と、「あなたと相手の受取額の案 A-2：あなたに X 円、相手に X 円」が示されています。

意思決定画面の右側には、左右に並んだ二つの選択肢から一つを選ぶ問題が縦に 11 個並んでいます。左側の選択肢は全て、案 A-1 が表示されています。右側の選択肢は、案 A-2 が、X=50 円から X=150 円まで 10 円刻みで X の値が変化した場合がそれぞれ示されています。それぞれの場合について、二つの選択肢のうち、あなたが好ましいと思う受取額の案をクリックしてください。

回数	1 / 1	残り時間 [秒]: 59
あなたと相手の受取額の案 A-1 あなたに150円、相手に250円	A-1: あなたに150円、相手に250円	A-2: あなたに50円、相手に50円
あなたと相手の受取額の案 A-2 あなたにX円、相手にX円	A-1: あなたに150円、相手に250円	A-2: あなたに60円、相手に60円
	A-1: あなたに150円、相手に250円	A-2: あなたに70円、相手に70円
	A-1: あなたに150円、相手に250円	A-2: あなたに80円、相手に80円
	A-1: あなたに150円、相手に250円	A-2: あなたに90円、相手に90円
	A-1: あなたに150円、相手に250円	A-2: あなたに100円、相手に100円
	A-1: あなたに150円、相手に250円	A-2: あなたに110円、相手に110円
	A-1: あなたに150円、相手に250円	A-2: あなたに120円、相手に120円
	A-1: あなたに150円、相手に250円	A-2: あなたに130円、相手に130円
	A-1: あなたに150円、相手に250円	A-2: あなたに140円、相手に140円
	A-1: あなたに150円、相手に250円	A-2: あなたに150円、相手に150円
		OK

図 1：問 A の意思決定画面

問 B の手順

問 B では、図 2 のような画面が表示されます。意思決定画面の左側には、「あなたと相手の受取額の案 B-1：あなたに 250 円、相手に 150 円」と、「あなたと相手の受取額の案 B-2：あなたに Y 円、相手に Y 円」が示されています。

意思決定画面の右側には、左右に並んだ二つの選択肢から一つを選ぶ問題が縦に 11 個並んでいます。左側の選択肢は全て、案 B-1 が表示されています。右側の選択肢は、案 B-2 が、Y=150 円から Y=250 円まで 10 円刻みで Y の値が変化した場合がそれぞれ示されています。それぞれの場合について、二つの選択肢のうち、あなたが好ましいと思う受取額の案をクリックしてください。

回数	1 / 1	残り時間 [秒]: 57
あなたと相手の受取額の案B-1 あなたに250円、相手に150円	B-1:あなたに250円、相手に150円	B-2:あなたに150円、相手に150円
あなたと相手の受取額の案B-2 あなたにY円、相手にY円	B-1:あなたに250円、相手に150円	B-2:あなたに160円、相手に160円
	B-1:あなたに250円、相手に150円	B-2:あなたに170円、相手に170円
	B-1:あなたに250円、相手に150円	B-2:あなたに180円、相手に180円
	B-1:あなたに250円、相手に150円	B-2:あなたに190円、相手に190円
	B-1:あなたに250円、相手に150円	B-2:あなたに200円、相手に200円
	B-1:あなたに250円、相手に150円	B-2:あなたに210円、相手に210円
	B-1:あなたに250円、相手に150円	B-2:あなたに220円、相手に220円
	B-1:あなたに250円、相手に150円	B-2:あなたに230円、相手に230円
	B-1:あなたに250円、相手に150円	B-2:あなたに240円、相手に240円
	B-1:あなたに250円、相手に150円	B-2:あなたに250円、相手に250円
		OK

図 2：問 B の意思決定画面

あなたが第 2 部の実験から得る実験謝金額の決まり方

あなたが第 2 部の実験によって獲得する謝金の額は次のように定まります。

まず、あなたとあなたの相手のいずれの回答が採用されるかが、無作為に決定されます。次に、選ばれた人の回答のうち、問 A での 11 個の回答と、問 B での 11 個の回答の、計 22 個の回答結果のなかから、一つの回答結果が無作為に選択されます。最後に、選ばれた問での回答結果の通りに、あなたと相手の受取額が決定します。

以上が第 2 部の実験の説明です。これから少し時間をとりますので、各自説明をよく読んでください。質問がある人は、静かに挙手してください。

D. Translated Experimental Instructions (English)

D.1. Instructions of the Team-production Task in *ONE*

Instructions

※ Please remember that you cannot communicate with others during the experiment, except to ask questions to the experimenter. The experiment will be stopped if this is violated.

※ The experiment will be performed on the personal computer (PC) in front of you, but please use it only as instructed. If not, we may stop the experiment.

Please ensure you have all of the following items. If anything is missing, please raise your hand.

- Instructions (this handout)
- A Record Sheet for Part 1
- A Plan (Attachment 1)
- A Record Sheet for the Final Results
- Writing utensils

Structure of this Experiment

The experiment consists of two parts, Part 1 and 2. The two parts are completely independent and separate experiments. The decisions you make in Part 1 will not affect the results of Part 2 and vice versa.

In both parts, please read the procedures carefully before making decisions. Following the explanation of the experiment, you will be given a quiz to ensure you have understood the explanation correctly. The payment rounds will not begin until everyone has answered this quiz correctly.

Your reward for this experiment is the sum of the amounts determined according to the results of the first and second part, plus a participation fee of JPY 800. The detailed method to determine the experimental rewards for Part 1 and Part 2 will be explained before each part begins.

Instructions: Part 1

Experimental Situation

In this experiment, we assume a production team consisting of two employees who work together to produce product α and a manager who decides the production plan for the team. You play the role of an employee. The manager's decisions are made by the PC based on the rules. Details, including the decision rules, will be explained later.

The production team will carry out production activities for one period, as shown in Fig. 1.

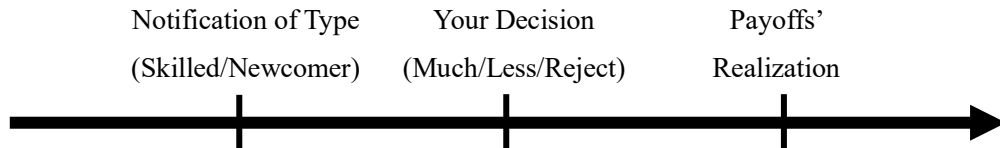


Fig. 1: The timeline of the production activity

There are two types of employees: skilled workers proficient in the production activity and newcomers who are not.

Two-thirds of you will be assigned the role of a skilled worker, and one-third will be assigned a newcomer's role. You do not know your teammates' type. Likewise, your teammate does not know your type.

Before the production activity starts, you will be informed whether your role is that of skilled worker or newcomer.

At the beginning of the production activity, the manager (PC) will ask each of the two employees how much they expect to produce. A plan for the team's production amount and each employee's rewards will be determined based on the responses.

Once the plan is determined, employees conduct their production activities as planned. At the end of the production activity, the manager (PC) pays each employee according to the plan. The employee's payoff is determined as "payoff = reward - the cost of production activity." The cost of production activity depends on the volume of production; the higher the volume, the higher the cost. Additionally, the cost of the same production activity for a skilled worker is lower than for a newcomer. Then, the production activity ends.

In this experiment, the discussed production activity will be repeated for 20 rounds. Whether you are a skilled worker or a newcomer, your role will be randomly reassigned in each round. When you are reassigned, there is a 2/3 chance that you will be a skilled worker and a 1/3 chance that you will be a newcomer, as in the first round. Also, your teammate will be randomly redetermined in each round.

The following sections describe the details of the rules and screen operations in chronological order.

Notification of Type

First, as shown in Figure 2, you will be notified whether you are assigned the role of a skilled worker or a newcomer.

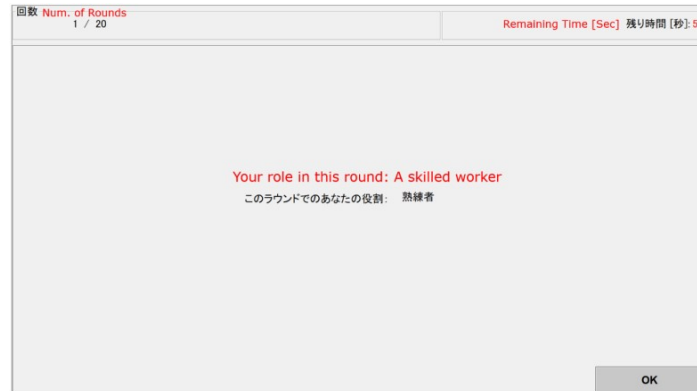


Fig. 2: Notification of Type screen (if you are a skilled worker)

Your Decision

Both you and your teammate will simultaneously indicate the expected production prospect from the following three alternatives: *Much*, *Less*, or *Reject*.

Much and *Less* imply large and small production amounts, respectively. If you select *Much*, you will do more production activities than if you select *Less*. *Reject*, on the other hand, means rejecting the entire plan and leaving the workplace. The production team can only perform a production activity if both employees are available. If one of the teammates selects *Reject*, no production activity will be performed, and everyone's payoff will be zero.

You will answer by clicking on the button of the corresponding alternative at the bottom of the decision-making screen shown in Figure 3. When you have finished, click on the OK button to proceed.

回数 Num. of Rounds
1 / 20

Teammate's Choice

Teammate's Payoff
(if a skilled worker)

Remaining Time [Sec] 残り時間 [秒]: 86

Your Choice

あなたの選択	チームメイト の選択	Your Payoff あなたの利得	チームメイトの利得 (熟練者の場合)	チームメイトの利得 (新人の場合)	Teammate's Payoff (if a newcomer)
Much	Much	560	560	-190	
	Less	615	500	380	
	Reject	0	0	0	
Less	Much	500	615	495	
	Less	427	427	380	
	Reject	0	0	0	
Reject	-	0	0	0	

Your role in this round: A skilled worker

このラウンドでのあなたの役割: 熟練者

あなたの行動を選択してください
Please select your behavior

☐ Much

☐ Less

☐ Reject

OK

Fig. 3: Decision-making screen (if you are a skilled worker)

The table displayed at the top of the decision-making screen in Figure 3 shows how the payoffs are determined according to you and your teammate's decisions. This table is the same as that in Attachment 1. Please refer to attachment 1 and pay attention to the

following explanation.

In the following sections, I explain a case where you are a skilled worker. As in the table entitled Skilled in Attachment 1, if you select *Much* and your teammate selects *Less*, your payoff is 615. Your teammate's payoff differs depending on their role: 500 if your teammate is a skilled worker and 380 if a newcomer. Thus, your payoff differs depending on you and your teammate's decisions and your role. We will give you time to understand it. Please review this carefully.

You may refer to Attachment 1 as and when required during the experiment.

How to Determine Your Experimental Reward from Part 1

Your reward from Part 1 is determined as follows.

First, one of the 20 rounds is selected randomly. We will tell you at the end of 20 rounds which one is chosen.

Your payoff in the selected round will be the amount of your experimental reward for Part 1. Note that one unit of payoff is equal to JPY 1. For example, if your payoff in the selected round is 615, your experimental reward for Part 1 is JPY 615.

This completes the explanation of Part 1. We will now take three minutes. Please read the explanation carefully and make sure you understand it. If you have any questions, please raise your hand quietly.

D.2. Instructions of the Team-production Task in *NOLEARN*

Instructions

※ Please remember that you cannot communicate with others during the experiment, except to ask questions to the experimenter. The experiment will be stopped if this is violated.

※ The experiment will be performed on the personal computer (PC) in front of you, but please use it only as instructed. If not, we may stop the experiment.

Please ensure you have all of the following items. If anything is missing, please raise your hand.

- Instructions (this handout)
- A Record Sheet for Part 1
- Plans for the First and Second Periods (Attachment 1)
- A Record Sheet for the Final Results
- Writing utensils

Structure of this Experiment

The experiment consists of two parts, Part 1 and 2. The two parts are completely independent and separate experiments. The decisions you make in Part 1 will not affect the results of Part 2 and vice versa.

In both parts, please read the procedures carefully before making decisions. Following the explanation of the experiment, you will be given a quiz to ensure you have understood the explanation correctly. The payment rounds will not begin until everyone has answered this quiz correctly.

Your reward for this experiment is the sum of the amounts determined according to the results of the first and second part, plus a participation fee of JPY 800. The detailed method to determine the experimental rewards for Part 1 and Part 2 will be explained before each part begins.

Instructions: Part 1

Experimental Situation

In this experiment, we assume a production team consisting of two employees who work together to produce product α and a manager who decides the production plan for the team. You play the role of an employee. The manager's decisions are made by the PC based on the rules. Details, including the decision rules, will be explained later.

This production team carries out production activities over two periods as shown in

Figure 1.

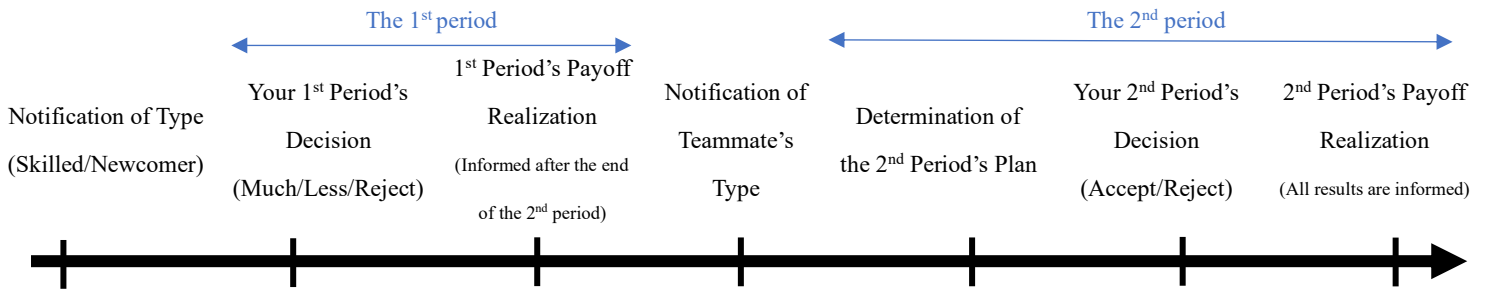


Fig. 1: The timeline of two periods

There are two types of employees: skilled workers proficient in the production activity and newcomers who are not.

Two-thirds of you will be assigned the role of a skilled worker, and one-third will be assigned a newcomer's role. You do not know your teammates' type. Likewise, your teammate does not know your type.

Before the production activity starts, you will be informed whether your role is that of skilled worker or newcomer.

At the beginning of the production activity, the manager (PC) will ask each of the two employees how much they expect to produce. A plan for the team's production amount and each employee's rewards will be determined based on the responses.

Once the plan is determined, employees conduct their production activities as planned. At the end of the production activity, the manager (PC) pays each employee according to the plan. The employee's payoff is determined as "payoff = reward - the cost of production activity." The cost of production activity depends on the volume of production; the higher the volume, the higher the cost. Additionally, the cost of the same production activity for a skilled worker is lower than for a newcomer. Then, the production activity ends.

During the transition from the first to the second period, you will know your teammates' ability level (either a skilled worker or a newcomer) as a result of conducting the production activity together as a team in the first period.

When the second period begins, the manager (PC) will determine the plan based on the employees' decisions in the first period.

After the plan is determined, each employee decides whether to carry out the production activity as planned and receive rewards or to reject the plan and leave the workplace. Depending on both employees' decisions, the outcome of the second period will be determined. Then, the second period ends.

In this experiment, the discussed production activity will be repeated for 20 rounds. Whether you are a skilled worker or a newcomer, your role will be randomly reassigned in each round. When you are reassigned, there is a 2/3 chance that you will be a skilled worker and a 1/3 chance that you will be a newcomer, as in the first round. Also, your teammate will be randomly redetermined in each round.

The following sections describe the details of the rules and screen operations in chronological order.

Notification of Type

First, as shown in Figure 2, you will be notified whether you are assigned the role of a skilled worker or a newcomer.

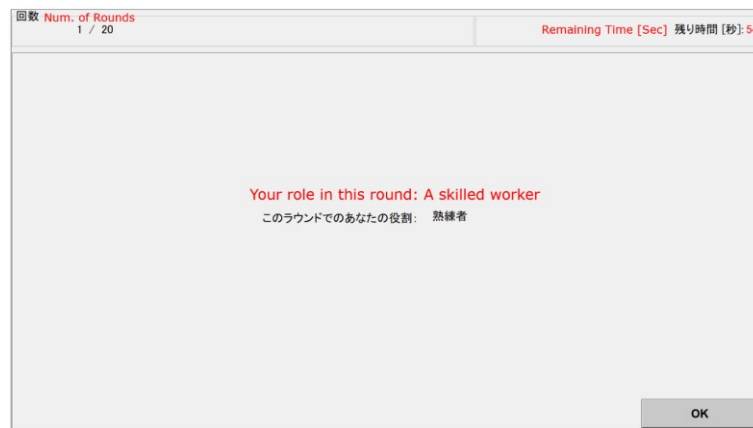


Fig. 2: Notification of Type screen (if you are a skilled worker)

Your First period's Decision

Both you and your teammate will simultaneously indicate the expected production prospect from the following three alternatives: *Much*, *Less*, or *Reject*.

Much and *Less* imply large and small production amounts, respectively. If you select *Much*, you will do more production activities than if you select *Less*. *Reject*, on the other hand, means rejecting the entire plan and leaving the workplace. The production team can only perform a production activity if both employees are available. If one of the teammates selects *Reject*, no production activity will be performed, and everyone's payoff will be zero.

You will answer by clicking on the button of the corresponding alternative at the bottom of the decision-making screen shown in Figure 3. When you have finished, click on the OK button to proceed.

回数 Num. of Rounds 1 / 20		Teammate's Choice		Teammate's Payoff (If a skilled worker)		Remaining Time [Sec] 残り時間 [秒]: 86
Your Choice あなたの選択	チームメイト の選択	Your Payoff あなたの利得	チームメイトの利得 (熟練者の場合)	チームメイトの利得 (新人の場合)	Teammate's Payoff (If a newcomer)	
	Much	Much	560	560		-190
	Less	Much	615	500		380
	Reject	Much	0	0		0
	Less	Less	500	615		495
Reject	Less	427	427	380		
Reject	Reject	0	0	0	0	
Reject	-	0	0	0	0	

Your role in this round: **A skilled worker**
 このラウンドでのあなたの役割: 熟練者

あなたの行動を選択してください
 Please select your 1st period's behavior

☐ Much
☐ Less
☐ Reject

OK

Fig. 3: Decision-making screen in the 1st period (if you are a skilled worker)

The table displayed at the top of the decision-making screen in Figure 3 shows how the payoffs are determined according to you and your teammate's decisions. This table is the same as that in Attachment 1. Please refer to attachment 1 and pay attention to the following explanation.

In the following sections, I explain a case where you are a skilled worker. As in the table entitled Skilled in Attachment 1, if you select *Much* and your teammate selects *Less*, your payoff is 615. Your teammate's payoff differs depending on their role: 500 if your teammate is a skilled worker and 380 if a newcomer. Thus, your payoff differs depending on you and your teammate's decisions and your role. We will give you time to understand it. Please review this carefully.

The results of the first period will be announced to everyone after the second period ends. You may refer to Attachment 1 as and when required during the experiment.

Notification of Teammate's Type

During the transition from the first to the second period, you will learn whether your teammate is a skilled worker or a newcomer. Your teammate's type will be notified on a screen, as shown in Figure 4.

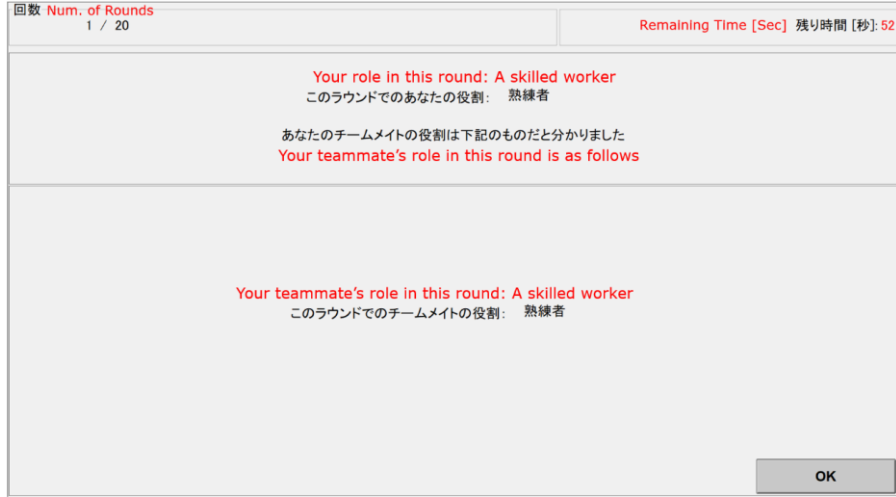


Fig. 4: Notification screen when you and your teammates are both skilled workers

Determination of the Second Period's Plan

Based on the employees' decisions in the first period, the plan for the second period is determined: the expected production and rewards for each employee in the second period. Table 1 shows how the pair of decisions in the first period corresponds to selecting the second period's plan.

As before, let us consider the case where you are a skilled worker. If you select *Much* in the first period and your teammate selects *Less*, then Plan B will be chosen as the plan for the second period.

Your Choice (1 st period)	Your Teammate's Choice (2 nd period)	2 nd period's Plan
<i>Much</i>	<i>Much</i>	A
<i>Much</i>	<i>Less</i>	B
<i>Less</i>	<i>Much</i>	C
<i>Less</i>	<i>Less</i>	D

Table 1: Correspondence between the 1st period's decisions and the 2nd period's plan

The plan chosen for the second period will be notified on the screen, as shown in Figure 5.

回数 Num. of Rounds 1 / 20		Remaining Time [Sec] 残り時間 [秒]: 46	
Your role in this round: A skilled worker このラウンドでのあなたの役割: 熟練者 このラウンドでのチームメイトの役割: 熟練者 Your teammate's role in this round: A skilled worker あなたとチームメイトの第一期での選択の結果、第二期の生産計画は下記のものに決まりました As a result of your decisions in the first period, the second period's plan is determined as follows.			
You and Your Teammate's Choices			OK
2 nd period's Plan 第二期 の計画	あなたと チームメイトの 選択	You Payoff あなたの利得	Your Teammate's Payoff チームメイトの利得
B	Both Accept	440	773
	Others	0	0

Fig. 5: Example of a notification screen for the 2nd period's plan (if you and your teammate are both skilled workers)

The specific amounts of payoffs in plans A through D are shown in Table (Skilled-2) and Table (Newcomer-2) in Attachment 1. The next section explains how to interpret these tables.

Your Second Period's Decision

After reviewing the screen shown in Figure 5, press the OK button and you will see the screen shown in Figure 6. At the top of the decision-making screen, you will see the same plan for the second period that you were just notified about.

回数 Num. of Rounds 1 / 20		Remaining Time [Sec] 残り時間 [秒]: 85	
Your Choice		Your Teammate's Choice	
あなたの 選択	チームメイト の選択	Your Payoff あなたの利得	Your Teammate's Payoff チームメイトの利得
Accept	Accept	440	773
	Reject	0	0
Reject	-	0	0
Your role in this round: A skilled worker このラウンドでのあなたの役割: 熟練者 第二期のあなたの行動を選択してください Please select your 2nd period's behavior ☐ Accept ☐ Reject			
			OK

Fig. 6: Decision-making screen in the 2nd period (if both are skilled workers)

You and your teammate will simultaneously select one of the two alternatives. The first alternative, *Accept*, is that you want to accept the plan displayed on the screen for the second period, perform the production activities, and receive the payoff as shown in the plan. The second alternative, *Reject*, is to reject the plan shown on the screen, receive zero, and leave the workplace without performing any production activities. Depending on the pair of decisions, the second period's outcome is determined, as shown in Table 2.

Let me explain how to interpret Table 2. If you and your teammate both select *Accept*, you will carry out the production activity in the second period as planned. However, if at least one of you selects *Reject*, you will not perform any production activities in the second period.

Your Choice (2 nd period)	Your Teammate's Choice (2 nd period)	Results of the 2 nd period
<i>Accept</i>	<i>Accept</i>	Conduct the production activity as planned
<i>Accept</i>	<i>Reject</i>	No production activity
<i>Reject</i>	<i>Accept</i>	
<i>Reject</i>	<i>Reject</i>	

Table 2: Correspondence between 2nd period's decisions and the 2nd period's results

I will provide an example of how the payoff in the second period is determined. As in the previous examples, suppose you and your teammate are both skilled workers; you selected *Much* and your teammate selected *Less* in the first period, and Plan B was chosen as the plan for the second period. If both of you select *Accept*, the payoff in the second period will be JPY 440 for you and JPY 773 for your teammate. However, if one of you selects *Reject*, both you and your teammate will receive zero in the second period.

How to Determine Your Experimental Reward from Part 1

Your reward from Part 1 is determined as follows.

First, one of the 20 rounds is selected randomly. We will tell you at the end of 20 rounds which one is chosen.

Your total payoff in the selected round will be the amount of your experimental reward for Part 1. Note that one unit of payoff is equal to JPY 1. For example, if your first period's payoff in the selected round is 615 and that in the second period is 440, then the experimental reward for Part 1 is $\text{JPY } 615 + 440 = \text{JPY } 1055$.

This completes the explanation of Part 1. We will now take three minutes. Please read the explanation carefully and make sure you understand it. If you have any questions, please raise your hand quietly.

D.3. Instructions of the Team-production Task in *LEARN*

Instructions

※ Please remember that you cannot communicate with others during the experiment, except to ask questions to the experimenter. The experiment will be stopped if this is violated.

※ The experiment will be performed on the personal computer (PC) in front of you, but please use it only as instructed. If not, we may stop the experiment.

Please ensure you have all of the following items. If anything is missing, please raise your hand.

- Instructions (this handout)
- A Record Sheet for Part 1
- Plans for the First and Second Periods (Attachment 1)
- A Record Sheet for the Final Results
- Writing utensils

Structure of this Experiment

The experiment consists of two parts, Part 1 and 2. The two parts are completely independent and separate experiments. The decisions you make in Part 1 will not affect the results of Part 2 and vice versa.

In both parts, please read the procedures carefully before making decisions. Following the explanation of the experiment, you will be given a quiz to ensure you have understood the explanation correctly. The payment rounds will not begin until everyone has answered this quiz correctly.

Your reward for this experiment is the sum of the amounts determined according to the results of the first and second part, plus a participation fee of JPY 800. The detailed method to determine the experimental rewards for Part 1 and Part 2 will be explained before each part begins.

Instructions: Part 1

Experimental Situation

In this experiment, we assume a production team consisting of two employees who work together to produce product α and a manager who decides the production plan for the team. You play the role of an employee. The manager's decisions are made by the PC based on the rules. Details, including the decision rules, will be explained later.

This production team carries out production activities over two periods as shown in

Figure 1.

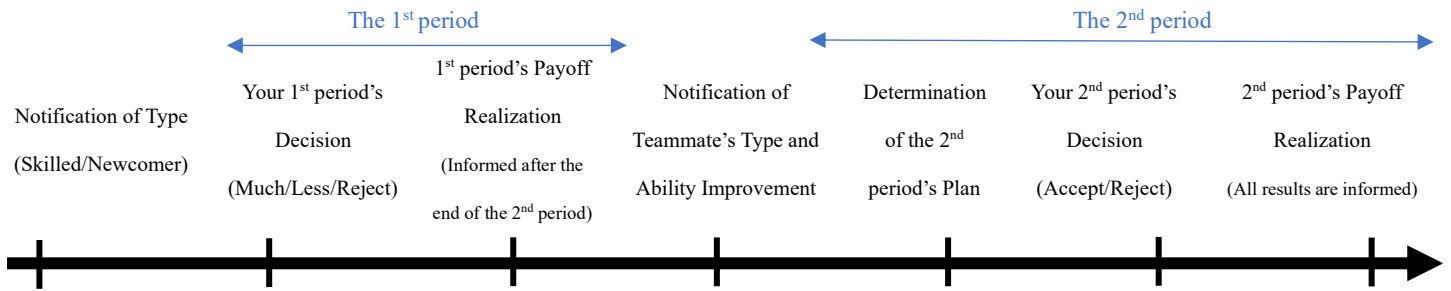


Fig. 1: The timeline of two periods

There are two types of employees: skilled workers proficient in the production activity and newcomers who are not.

Two-thirds of you will be assigned the role of a skilled worker, and one-third will be assigned a newcomer's role. You do not know your teammates' type. Likewise, your teammate does not know your type.

Before the production activity starts, you will be informed whether your role is that of skilled worker or newcomer.

At the beginning of the production activity, the manager (PC) will ask each of the two employees how much they expect to produce. A plan for the team's production amount and each employee's rewards will be determined based on the responses.

Once the plan is determined, employees conduct their production activities as planned. At the end of the production activity, the manager (PC) pays each employee according to the plan. The employee's payoff is determined as "payoff = reward - the cost of production activity." The cost of production activity depends on the volume of production; the higher the volume, the higher the cost. Additionally, the cost of the same production activity for a skilled worker is lower than for a newcomer. Then, the production activity ends.

During the transition from the first to the second period, the following two will occur. First, you will know your teammates' ability level (either a skilled worker or a newcomer) as a result of conducting the production activity together as a team in the first period. Second, newcomers whose teammates are skilled workers will improve their abilities by learning from working with a skilled worker in the first period.

When the second period begins, the manager (PC) will determine the plan based on the employees' decisions in the first period.

After the plan is determined, each employee decides whether to carry out the production activity as planned and receive rewards or to reject the plan and leave the

workplace. Depending on both employees' decisions, the outcome of the second period will be determined. Then, the second period ends.

In this experiment, the discussed production activity will be repeated for 20 rounds. Whether you are a skilled worker or a newcomer, your role will be randomly reassigned in each round. When you are reassigned, there is a 2/3 chance that you will be a skilled worker and a 1/3 chance that you will be a newcomer, as in the first round. Also, your teammate will be randomly redetermined in each round.

The following sections describe the details of the rules and screen operations in chronological order.

Notification of Type

First, as shown in Figure 2, you will be notified whether you are assigned the role of a skilled worker or a newcomer.

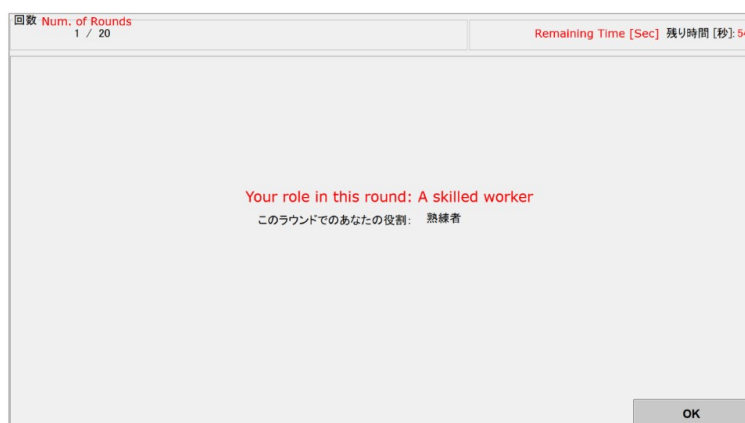


Fig. 2: Notification of Type screen (if you are a skilled worker)

Your First period's Decision

Both you and your teammate will simultaneously indicate the expected production prospect from the following three alternatives: *Much*, *Less*, or *Reject*.

Much and *Less* imply large and small production amounts, respectively. If you select *Much*, you will do more production activities than if you select *Less*. *Reject*, on the other hand, means rejecting the entire plan and leaving the workplace. The production team can only perform a production activity if both employees are available. If one of the teammates selects *Reject*, no production activity will be performed, and everyone's payoff will be zero.

You will answer by clicking on the button of the corresponding alternative at the bottom of the decision-making screen shown in Figure 3. When you have finished, click on the OK button to proceed.

回数 Num. of Rounds 1 / 20		Teammate's Choice		Teammate's Payoff (if a skilled worker)		Remaining Time [Sec] 残り時間 [秒]: 86
Your Choice	あなたの 選択	チームメイト の選択	Your Payoff あなたの利得	チームメイトの利得 (熟練者の場合)	チームメイトの利得 (新人の場合)	Teammate's Payoff (if a newcomer)
Much	Much		560	560	-190	
	Less		615	500	380	
	Reject		0	0	0	
Less	Much		500	615	495	
	Less		427	427	380	
	Reject		0	0	0	
Reject	-		0	0	0	

Your role in this round: A skilled worker
 このラウンドでのあなたの役割: 熟練者

あなたの行動を選択してください
 Please select your 1st period's behavior

☐ Much
☐ Less
☐ Reject

OK

Fig. 3: Decision-making screen in the 1st period (if you are a skilled worker)

The table displayed at the top of the decision-making screen in Figure 3 shows how the payoffs are determined according to you and your teammate's decisions. This table is the same as that in Attachment 1. Please refer to attachment 1 and pay attention to the following explanation.

In the following sections, I explain a case where you are a skilled worker. As in the table entitled Skilled in Attachment 1, if you select *Much* and your teammate selects *Less*, your payoff is 615. Your teammate's payoff differs depending on their role: 500 if your teammate is a skilled worker and 380 if a newcomer. Thus, your payoff differs depending on you and your teammate's decisions and your role. We will give you time to understand it. Please review this carefully.

The results of the first period will be announced to everyone after the second period ends. You may refer to Attachment 1 as and when required during the experiment.

Notification of Teammate's Type and Ability Improvement

During the transition from the first to the second period, you will learn whether your teammate is a skilled worker or a newcomer. Additionally, newcomers whose teammates are skilled workers will improve their ability due to their learning while working with a skilled worker in the first period. After the improvement, the newcomer's ability level is the same as that of the skilled worker. Note that if the teammate is also a newcomer, the newcomer's ability improvement will not occur. Additionally, the skilled worker's ability is already high enough, so no matter whom he teams up with, the skilled worker's ability will not improve.

The type of teammate and the results of ability improvement will be notified on the

screen, as shown in Figures 4, 5, and 6 below.

回数 Num. of Rounds	Remaining Time [Sec] 残り時間 [秒]
1 / 20	6
Your role in this round: A newcomer このラウンドでのあなたの役割: 新人 あなたのチームメイトの役割は下記のものと分かりました Your teammate's role in this round is as follows	
Your teammate's role in this round: A skilled worker このラウンドでのチームメイトの役割: 熟練者 チームメイトが熟練者のため、あなたの能力は向上しました あなたの能力は熟練者と同じ水準になりました Since your teammate is a skilled worker, your ability has improved Your ability level has become equal to that of the skilled workers	
OK	

Fig. 4: When you are a newcomer and your teammate is a skilled worker

回数 Num. of Rounds	Remaining Time [Sec] 残り時間 [秒]
1 / 20	3
Your role in this round: A newcomer このラウンドでのあなたの役割: 新人 チームメイトの役割と能力向上は下記の通りだと分かりました Your teammate's role in this round is as follows	
Your teammate's role in this round: A newcomer このラウンドでのチームメイトの役割: 新人 あなたとチームメイトの双方が新人のため、能力向上は起きませんでした あなたとチームメイトの能力は第一期の水準のまま変化ありません Since your teammate is a newcomer, your ability has not improved Both you and your teammate's ability level stay the same with the first period's level	
OK	

Fig. 5: When both you and your teammate are newcomers

回数 Num. of Rounds 1 / 20	Remaining Time [Sec] 残り時間 [秒]: 20
Your role in this round: A skilled worker このラウンドでのあなたの役割: 熟練者 チームメイトの役割と能力向上は下記の通りだと分かりました Your teammate's role in this round is as follows	
Your teammate's role in this round: A skilled worker このラウンドでのチームメイトの役割: 熟練者 あなたもチームメイトも既に能力の高い熟練者であるため、更なる能力向上は起きませんでした あなたとチームメイトの能力は第一期の水準のまま変化ありません Since you and your teammates are already highly competent skilled workers, no further improvement in your abilities occurred Both you and your teammate's ability level stay the same with the first period's level	
OK	

Fig. 6: When both you and your teammate are skilled workers

Determination of the Second Period's Plan

Based on the employees' decisions in the first period, the plan for the second period is determined: the expected production and rewards for each employee in the second period. Table 1 shows how the pair of decisions in the first period corresponds to selecting the second period's plan.

As before, let us consider the case where you are a skilled worker. If you select *Much* in the first period and your teammate selects *Less*, then Plan B will be chosen as the plan for the second period.

Your Choice (1 st period)	Your Teammate's Choice (2 nd period)	2 nd period's Plan
<i>Much</i>	<i>Much</i>	X
<i>Much</i>	<i>Less</i>	
<i>Less</i>	<i>Much</i>	
<i>Less</i>	<i>Less</i>	Y

Table 1: Correspondence between the 1st period's decisions and the 2nd period's plan

The plan chosen for the second period will be notified on the screen, as shown in Figure 7.

回数 Num. of Rounds 1 / 20		Remaining Time [Sec] 残り時間 [秒]: 37	
Your role in this round: A skilled worker このラウンドでのあなたの役割: 熟練者 Your teammate's role in this round: A skilled worker このラウンドでのチームメイトの役割: 熟練者 あなたとチームメイトの第一期での選択の結果、第二期の生産計画は下記のものに決まりました Based on you and your teammate's decisions in the first period, the second period's plan is determined as follows			
You and Your Teammate's Choice OK			
2nd period's plan 第二期 の計画	あなたと チームメイトの 選択	Your Payoff あなたの利得	Your Teammate's Payoff チームメイトの利得
X	Both Accept	440	440
	Others	0	0

Fig. 7: Example of a notification screen of the 2nd period's plan (when you and your teammates are both skilled)

The specific amounts of payoffs in plans A through D are shown in Table (Skilled-2) and Table (Newcomer-2) in Attachment 1. The next section explains how to interpret these tables.

Your Second Period's Decision

After reviewing the screen shown in Figure 7, press the OK button and you will see the screen shown in Figure 8. At the top of the decision-making screen, you will see the same plan for the second period that you were just notified about.

回数 Num. of Rounds 1 / 20		Remaining Time [Sec] 残り時間 [秒]: 83	
Your Choice		Your Teammate's Choice	
あなたの 選択	チームメイト の選択	Your Payoff あなたの利得	Your Teammate's Payoff チームメイトの利得
Accept	Accept	440	440
	Reject	0	0
Reject	-	0	0

Your role in this round: A skilled worker
このラウンドでのあなたの役割: 熟練者

第二期のあなたの行動を選択してください
Please select your 2nd period's behavior

☐ Accept
☐ Reject

OK

Fig. 8: Example of a decision-making screen for the second period (when you and your teammates are both skilled)

You and your teammate will simultaneously select one of the two alternatives. The first alternative, *Accept*, is that you want to accept the plan displayed on the screen for the second period, perform the production activities, and receive the payoff as shown in

the plan. The second alternative, *Reject*, is to reject the plan shown on the screen, receive zero, and leave the workplace without performing any production activities. Depending on the pair of decisions, the second period's outcome is determined, as shown in Table 2.

Let me explain how to interpret Table 2. If you and your teammate both select *Accept*, you will carry out the production activity in the second period as planned. However, if at least one of you selects *Reject*, you will not perform any production activities in the second period.

Your Choice (2 nd period)	Your Teammate's Choice (2 nd period)	Results of the 2 nd period
<i>Accept</i>	<i>Accept</i>	Conduct the production activity as planned
<i>Accept</i>	<i>Reject</i>	No production activity
<i>Reject</i>	<i>Accept</i>	
<i>Reject</i>	<i>Reject</i>	

Table 2: Correspondence between 2nd period's decisions and the 2nd period's results

I will provide an example of how the payoff in the second period is determined. As in the previous examples, suppose you and your teammate are both skilled workers; you selected *Much* and your teammate selected *Less* in the first period, and Plan B was chosen as the plan for the second period. If both of you select *Accept*, the payoff in the second period will be JPY 440 for you and JPY 773 for your teammate. However, if one of you selects *Reject*, both you and your teammate will receive zero in the second period.

How to Determine Your Experimental Reward from Part 1

Your reward from Part 1 is determined as follows.

First, one of the 20 rounds is selected randomly. We will tell you at the end of 20 rounds which one is chosen.

Your payoff in the selected round will be the amount of your experimental reward for Part 1. Note that one unit of payoff is equal to JPY 1. For example, if your first period's payoff in the selected round is 615 and that in the second period is 440, then your experimental reward for Part 1 is $\text{JPY } 615 + 440 = \text{JPY } 1055$.

This completes the explanation of Part 1. We will now take three minutes. Please read the explanation carefully and make sure you understand it. If you have any questions, please raise your hand quietly.

D.4. Instructions of the Task for Measuring Inequity Aversion

Instructions: Part 2

Experimental Situation

You will be randomly divided into pairs. You will work on a task to determine the amount of money that each of you will receive. You will be asked to provide your opinion on the amount of money received. After you have answered, one out of two persons will be chosen at random, and the payment will be made according to the opinion of the chosen person.

You will be asked two questions, A and B. They are similar in format, but the proposed receiving amount is different, so please answer them carefully. Next, we will explain the detailed procedure for Questions A and B.

Procedure of Question A

In Question A, you will see a screen as shown in Figure 1. On the left side of the screen, you will see “Proposal A-1: JPY 150 for you and JPY 250 for the other party” and “Proposal A-2: JPY X for you and JPY X for the other party.”

On the right side of the screen, there are 11 questions lined up vertically to choose one of the two options lined up on the left. All the alternatives on the left side show proposal A-1. The right-hand side shows proposal A-2, where the value of X changes in JPY 10 increments from X= JPY 50 to X= JPY 150. For each case, click on the option that you prefer to receive.

回数 Num. of Rounds 1 / 1	Remaining Time [Sec] 残り時間 [秒]: 59	
Proposal A-1 You receive ¥150, The other part receives ¥250	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥50, The other part receives ¥50 A-2: あなたに50円、相手に50円
あなたと相手の受取額の案A-1 あなたに150円、相手に250円	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥60, The other part receives ¥60 A-2: あなたに60円、相手に60円
あなたと相手の受取額の案A-2 あなたにX円、相手にX円	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥70, The other part receives ¥70 A-2: あなたに70円、相手に70円
Proposal A-2 You receive ¥X, The other part receives ¥X	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥80, The other part receives ¥80 A-2: あなたに80円、相手に80円
	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥90, The other part receives ¥90 A-2: あなたに90円、相手に90円
	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥100, The other part receives ¥100 A-2: あなたに100円、相手に100円
	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥110, The other part receives ¥110 A-2: あなたに110円、相手に110円
	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥120, The other part receives ¥120 A-2: あなたに120円、相手に120円
	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥130, The other part receives ¥130 A-2: あなたに130円、相手に130円
	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥140, The other part receives ¥140 A-2: あなたに140円、相手に140円
	You receive ¥150, The other part receives ¥250 A-1: あなたに150円、相手に250円	You receive ¥150, The other part receives ¥150 A-2: あなたに150円、相手に150円
		OK

Fig. 1: A decision-making screen for Question 1

Procedure of Question B

In Question B, you will see a screen as shown in Figure 2. On the left side of the screen, you will see “Proposal B-1: JPY 250 for you and JPY 150 for the other party” and “Proposal B-2: JPY X for you and JPY X for the other party.”

On the right side of the screen, there are 11 questions lined up vertically to choose one of the two options lined up on the left. All the alternatives on the left side show proposal B-1. The right-hand side shows proposal B-2, where the value of X changes in JPY 10 increments from X= JPY 150 to X= JPY 250. For each case, click on the option that you prefer to receive.

回数 Num. of Rounds 1 / 1		Remaining Time [Sec] 残り時間 [秒]: 57
Proposal B-1 You receive ¥250, The other part receives ¥150 あなたと相手の受取額の案B-1 あなたに250円、相手に150円 Proposal B-2 You receive ¥X, The other part receives ¥X あなたと相手の受取額の案B-2 あなたにY円、相手にY円	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥150, The other part receives ¥150 B-2: あなたに150円、相手に150円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥160, The other part receives ¥160 B-2: あなたに160円、相手に160円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥170, The other part receives ¥170 B-2: あなたに170円、相手に170円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥180, The other part receives ¥180 B-2: あなたに180円、相手に180円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥190, The other part receives ¥190 B-2: あなたに190円、相手に190円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥200, The other part receives ¥200 B-2: あなたに200円、相手に200円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥210, The other part receives ¥210 B-2: あなたに210円、相手に210円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥220, The other part receives ¥220 B-2: あなたに220円、相手に220円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥230, The other part receives ¥230 B-2: あなたに230円、相手に230円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥240, The other part receives ¥240 B-2: あなたに240円、相手に240円
	You receive ¥250, The other part receives ¥150 B-1: あなたに250円、相手に150円	☐ You receive ¥250, The other part receives ¥250 B-2: あなたに250円、相手に250円

OK

Fig. 2: A decision-making screen for Question 2

How to Determine Your Experimental Reward from Part 2

Your experimental reward from Part 2 will be determined as follows.

First, either you or your partner will be randomly selected. Next, among the 22 answers (11 from Question A and 11 from Question B), one of the answers is randomly selected. Finally, the amount of money you and your partner receive will be determined according to the selected question’s answer.

This completes the explanation of Part 2. We will now take a few minutes; please read the explanation carefully and ensure you understand it. If you have any questions, please raise your hand quietly.