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Subsidies to Public Firms and Competition Modes under a Mixed Duopoly[1]

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Abstract

This study experimentally examines whether subsidies to a state-owned enterprises (SOE) change the behavior of a private firm or the SOE under a mixed duopoly. Following Hampton and Sherstyuk (2012), we conducted a series of laboratory experiments adopting a two-stage capacity-price decision-making duopoly setting. We adopted two treatments in terms of types of subsidies: one is a subsidy for production/sales and the other is a subsidy for capacity building. The results indicate that even a small amount of subsidy can influence the choices of capacities and prices of both types of firms. Production subsidies increase capacities of both private firms and SOEs, and, accordingly, the prices of both types of firms decrease, while capacity subsidies decrease capacities of private firms. Because the competition for capacity building between two firms becomes less severe, the profits of both firms increase and, interestingly, the idle capacities of private firms decrease. Moreover, both social and domestic surpluses increase in the case of production subsidies, but decrease in the case of capacity subsidy. In the former case, severe competition mitigates the distortion caused by imperfect competition. We also find that the firm attributes and behavior in the past significantly influence capacity choices.

Keywords: Laboratory experiments, Mixed duopoly, State-owned enterprises, Competition modes.
JEL classification: H25, H44, L13, L32.

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1. Introduction

The positive and negative effects of the entry of state-owned enterprises (**SOE**s) into markets have been discussed for the past several decades, both in the academic field and political arena.[2] Because the objective of SOEs is theoretically the weighted sum of profits and social surplus, entry of an SOE into a market increases social surplus when the market is imperfectly competitive. The entry lowers prices and increases consumption and, accordingly, consumer surplus. The market structure that contains both private firms and SOEs is called a mixed oligopoly. [3] Many articles have theoretically examined mixed oligopoly in the past few decades (Matsumura, 1998; Matsumura, 2003; Matsumura and Matsushima, 2004; Lu and Poddar, 2006; Ishibashi and Kaneko, 2008; Ohnishi, 2009; Kitahara and Matsumura, 2013; Luo, 2013, among others). Several articles have also investigated regulations and subsidies relating to mixed oligopoly (for example, Matsumura, 2012; Scrimitore, 2014).

However, when we consider subsidies to SOEs, the problem is not only a domestic one but also an international issue in the real world. Consider an example in which both domestic SOEs and foreign private firms are engaged in a product market. If the government provides subsidies to the domestic SOEs, the situation becomes unfavorable for foreign private firms. In general, a production subsidy acts like a decrease in marginal production cost, making a subsidized SOE more competitive against private firms. This may drive out foreign private firms from the domestic market. Even when they compete with each other in an international market, subsidies gives SOEs a stronger incentive to increase their outputs, which leads to a decrease in the price of the product, not because of any innovation by the SOEs, but because of the subsidies. Thus, private firms lose their profits. Moreover, in contrast to subsidies to

[2] *Public firm* is usually used for this type of firm in the field of economics. However, considering the purpose of this paper and the ongoing RIETI project, we use *state-owned firm* (*SOE*) in this paper.
[3] When one private firm and one SOE enter a market, the market structure is referred to as mixed duopoly.

private firms, subsidies to SOEs are likely to be easily excessive because of political reasons; SOEs usually have networks and connections with authorities that manage subsidies. Moreover, the objectives of managers in SOEs are often neither profit maximization nor welfare maximization. Rather, they may act to obtain power in their institutions or political power. The World Trade Organization has been discussing subsidies for SOEs for the past decade in its negotiations.[4] Similar to other subsidies, this type of subsidy is strictly restricted for partner countries to use.

As noted above, mixed oligopoly has been theoretically analyzed in detail in the field of economics. However, there is little experimental evidence for this market structure. Although Du et al. (2013) carried out an experiment under the structure of mixed duopoly and observed the behavior of a public firm, they focused on a delegation problem. The merit of using experimental methods to analyze the effect of subsidies for SOEs under mixed oligopoly is that changes in the competition structure can be observed and clarified. Theoretical studies focus on issues relating to the characteristics of markets and firms, such as quality, product differentiation, uncertainty, and partial privatization given the competition mode. However, government subsidies to SOEs can change the competition structures between private firms and SOEs. An experimental approach is able to elucidate these changes caused by policy changes.

The purpose of this paper is to clarify the effect of SOE subsidies on capacities, prices, and profits of both a private firm and an SOE under the setting of mixed duopoly. We also examine if this type of subsidy is harmful by investigating the effect on social surplus. To this end, we adopt a two-stage capacity-price decision-making setting. In this setting, subjects choose their capacities simultaneously in the first stage and, then, choose their prices

[4] Several articles examined international mixed oligopoly and international trade issues (Chang, 2007; Ohnishi, 2008; Lee et al., 2013; Ou et al, 2016).

simultaneously in the second stage, during which we consider the factors of both quantity and price competition. Kreps and Scheinkman (1983) set up the theoretical model and proved that the equilibrium outputs are the same as those in Cournot equilibrium. [5] The two-stage decision-making structure has been used for experimental studies under oligopoly (Davis, 1999; Muren, 2000; Goodwin and Mestelman, 2010; Hampton and Sherstyuk, 2012). In contrast to the theory of mixed oligopoly, all of the firms' capacities are not necessarily used for production in the second stage. Idle capacities may exist when subjects hold capacities excessively in the first stage and when they give up using part of their capacities for production to avoid a sharp drop in the price.

This paper has three features. First, we examine two types of subsidies for SOEs: a production/sales subsidy and a capacity subsidy. The former subsidy is provided according to the sales/production amount, which implies that this subsidy directly influences the decision-making of SOEs in the second stage. In comparison, the latter is provided according to the amount of capacity holding, which implies that this subsidy directly influences the decision-making of SOEs in the first stage. Even if capacities are not used for production (idle), the SOEs receive subsidies.

Second, we carry out several treatments for a production subsidy, with different amounts of per unit production subsidy across treatments. We introduce these treatments because the amounts of subsidy may also influence the degree of responses by SOEs and, accordingly, by private firms.

Third, we consider not only social surplus but also domestic surplus. Social surplus, which is defined as the sum of consumer surplus and profits of both the private firm and the SOE, is equivalent to world welfare in the context of international trade theory if the private firm is a

[5] Durham et al. (2004) examined the oligopolistic competition in the presence of fixed cost for capacity holding.

foreign firm and the SOE is a home/domestic firm. On the other hand, if the objective of the domestic government is to maximize domestic surplus, the profits of the foreign private firm are excluded from the objective function. Hence, we also consider domestic surplus, which is defined as the sum of consumer surplus and the profits of the SOE.

The main results are as follows. First, even a small amount of subsidy can influence the choices of capacities and prices of both types of firms. Second, a production subsidy increases the capacities of both private firms and SOEs and, accordingly, the prices of both types of firms' products decrease. These changes indicate that quantity competition becomes more severe after a subsidy is provided. Third, on the other hand, a capacity subsidy decreases the capacities of private firms while the capacities of SOEs increase. Because the former effect dominates the latter effect, total capacities also decrease. With a capacity subsidy, the quantity competition between both types of firms is less severe, the profits of both types of firms increase and, interestingly, the idle capacities of private firms decrease. Fourth, both social and domestic surpluses increase in the case of a production subsidy but decrease in the case of a capacity subsidy. In the former case, the severe competition mitigates the distortion caused by imperfect competition. Fifth, the firm attributes and behavior in the past significantly influence capacity choices and price setting. Whether a firm is a private one or an SOE significantly influences capacity choices; in some cases, capacity choices and price setting are influenced by the behavior of the partner in the previous round.

The structure of the rest of the paper is as follows. Section 2 describes the design of the experiment sessions. Section 3 reports the results of the experiment. Section 4 discuss policy implication, and Section 5 provides concluding remarks.

2. Design of the Experiment

2.1 Design and Demand Structure

We follow the basic design used in Hampton and Sherstyuk (2012), which is a type of two-stage capacity-price-choice duopoly model. Two subjects are randomly paired in each session, and they stay in the same market throughout the session they participate in. Both subjects act as sellers in the market under specified demand conditions that are certainly known to them. Basically, each round consists of two stages. First, both subjects make simultaneous capacity choices. When both/all the subjects determine their capacities, each subject is informed about the capacity chosen by the other and the total capacity of the market that s/he enters. Second, each subject chooses a price simultaneously. As explained in the next subsection, one of the two subjects plays the role of a private firm, while the other plays the role of an SOE in the quantity-price-setting game.

Each seller faces a constant marginal cost for holding capacity, which is 20 experimental dollars per unit.[6] As our purpose is to observe individual behavior and market situations with production/capacity subsidies, we exclude the fixed cost because it makes the structure of the experiment complicated and confusing. However, subjects must pay marginal costs according to the capacity they possess rather than the amounts of goods produced. Even if the production amount is smaller than the capacity, the cost is equal to 20 experimental dollars times the capacity. Thus, this marginal cost for holding additional capacity may act as a fixed cost in the sense that the cost is sunk when they choose their prices.

Throughout the experiment, the subjects face a demand condition given by the following formula:

$$Q = 200 - 2p \tag{1}$$

where Q and p denote the total supply by the two entrants and the market price, respectively. Each experiment session consists of two phases, the details of which are explained in the next subsection. The first phase, which is referred to as Phase 1, consists of ten rounds, while the

[6] We use the term "experimental dollars" for the money used in the experiment sessions.

second phase, which is referred to as Phase 2, consists of eight or seven rounds.

In the experiment, the table of quantities and prices that reflects demand condition (1) is distributed at the beginning of the experiment (See Figure 1).

2.2 Treatments

As noted above, one person in each pair plays the role of a private firm, while the other plays the role of an SOE. The objective of the former player is the maximization of his/her own profits throughout the experiment. Each subject who plays the role of a private firm recognizes that her/his acquired points/rewards in the experiment (acquired experimental dollars) are defined as follows:

$$Acquiγed\ expeγimeηtαl\ dollαγs\ foγ\ α\ pγivαte\ fiγm = Pγofits$$

In the following, we also use *rewards* to refer to acquired experimental dollars, which maybe different from profits.

We conducted two main treatments and three additional treatments in terms of the objectives of the latter player (SOE). In Phase 1, the objective of an SOE is common for the two main treatments, which is defined as follows:

$$Acquiγed\ expeγimeηtαl\ dollαγs\ foγ\ αη\ SOE = 0.7 \times Pγofits + Sαles$$

This objective implies that the marginal cost of capacity holding is decreased by approximately 1.43, as long as the capacity is used for production. In other words, capacity holding is not directly subsidized. SOEs have stronger incentives to produce than private firms do. Unless the total production amount is greater than 160, the behavior of the private firm increases social surplus.

The objectives of an SOE in Phase 2 are different between the treatments. In the first main treatment (SS3), the objective of an SOE is defined as follows:

$$Acquiγed\ expeγimeηtαl\ dollαγs\ foγ\ α\ SOE = 0.7 \times Pγofits + 4 \times Sαles.$$

Each SOE has a stronger incentive to increase its production/sales in Phase 2 than in Phase 1. This change implies that the production/sales subsidy provided to the SOE increases. In the following analysis, we refer to this type of subsidy as a production subsidy.

In the second main treatment (CS3), the objective of an SOE in Phase 2 is defined as follows:

$$Acquiγed\ expeγimeηtαl\ dollαγs\ foγ\ αη\ SOE = 0.7 \times Pγofits + Sαles + 3 \times Cαpacities$$

In contrast to treatment SS3, each SOE has a stronger incentive to increase its capacities in Phase 2 than in Phase 1. This change also considers that the capacity subsidy provided to the SOE increases. Note that capacity holding is subsidized even if the capacity is idle.

To verify the effect of an increased amount of production subsidy and the effect of a new starting level of production subsidy, we conducted three additional treatments, which are referred to as SS1, SS5, and SS9. Similar to the main treatments, the objective of a private firm is the maximization of its own profits in both phases.

The objective of an SOE in Phase 1 of SS1 and SS5 are the same as that of SS3. On the other hand, the objectives of an SOE in Phase 2 of SS1 and SS5 are defined as follows:

$$Acquiγed\ expeγimeηtαl\ dollαγs\ foγ\ α\ SOE = 0.7 \times Pγofits + 2 \times Sαles,$$

and

$$Acquiγed\ expeγimeηtαl\ dollαγs\ foγ\ α\ SOE = 0.7 \times Pγofits + 6 \times Sαles,$$

respectively. The effect of an increase in the production subsidy in treatment SS1 are expected to be smaller than that in treatment SS3, while the effect of an increase in the production subsidy in SS5 are expected to be larger than that in SS3.

Finally, the starting level of an incentive of an SOE to increase its production/sales in SS9 is different from that in the other treatments. The objective of an SOE in Phase 1 is defined as follows:

$$Acquired\ experimental\ dollars\ for\ a\ SOE = 0.7 \times Profits + 6 \times Sales.$$

On the other hand, the increase in the production subsidy in SS9 is the same as that in SS3. Thus, the objective of an SOE in Phase 2 is defined as follows:

$$Acquired\ experimental\ dollars\ for\ a\ SOE = 0.7 \times Profits + 9 \times Sales.$$

2.3 Sessions and Procedures

We conducted three SS3 and three CS3 treatments. Moreover, we conducted one SS1, one SS5, and two SS9 treatments. In each session, the number of participants were eight, ten, or twelve, which implies that the number of markets in each session was four, five, or six. The participants were undergraduate students of Kwansei Gakuin University. See Table 1 for the details of the sessions. We did not exclude students of any specific departments. Thus, our sample includes students who specialize in various fields, including business, economics, law, literature, and social studies. Each student participated in only one session, and those students were paid an average of ¥3533.467 based on their results.[7] In the beginning of each session, the subjects answered a questionnaire intended to measure their risk preference and, then, they were directed to read the instructions for about 10 minutes. [8] Then, for a more precise understanding of the instructions, an instructor read them out loud.

In each round, the subjects were given 30 seconds to determine their capacities in Stage 1. When all the subjects determined their capacities, they proceeded to Stage 2. At this stage, the subjects were given 70 seconds to determine their prices. They were allowed to use the

[7] Before the subjects began the capacity-price-setting game, they were told that 6 experimental dollars would be converted into ¥1 for real payments. However, before we began the series of the experiment sessions, we expected that the acquired experimental dollars would be greater than those the subjects actually acquired. Thus, in the first two sessions, both of which are SS9 treatments, subjects are told that 12 and 8 experimental dollars would be converted into ¥1 for real payments. However, in the end of those sessions, the subjects were told that the conversion rate was changed to "6 experimental dollars = ¥1."

[8] See Figure 2 for this questionnaire.

calculator function on their computer screens. When a subject determined the price, s/he entered the price and clicked the “OK” button. When all subjects determined their prices, they proceeded to the recording stage, in which they wrote down the results. They saw sales amounts, prices, and profits of both participants and their own acquired experimental dollars on the screen. This recording stage continued for 20 seconds.

In this paper, we use technical terms specific to industry and cartels to describe the experiment design and the results. However, in the experiment, the subjects were shown more neutral terminologies. Moreover, in the following sections, we refer to the human participants who play the roles of private firms in the experiment as "private firms" and the participants who play the roles of SOEs as "SOEs” for brevity. We conducted the experiment using the University of Zurich’s A-tree program (Fischbacher, 1999).

3. Results

3.1 Market Variables

First, we look at the aggregate data, averages, and standard deviations to get an overview of the outcomes of the experiment. For our mixed duopoly experiment, there are two benchmark pairs of capacities and prices.

The first benchmark is a Cournot equilibrium with two private firms. Suppose that both firms are private firms and choose capacities and quantities in each stage to maximize their own profits. According to Kreps and Scheinkman (1983), the equilibrium capacities and, accordingly, the prices are theoretically the same as those of a Cournot equilibrium. That is, each firm’s capacity/sales, total capacity/sales, and prices are $160/3$, $320/3$, and $140/3$, respectively. The second benchmark is a Bertrand equilibrium with two private firms. Because the marginal cost of capacity/production is 20, the total capacity/sales and price in equilibrium are 160 and 20, respectively. Figures 3 and 4 show the trend of average market capacities,

prices, and sales of SS3 and CS3 (the two main treatments), respectively. According to these figures, the market values seem to be between those of Cournot and Bertrand equilibria with two private firms in Phase 1. These trends are similar to the results of Hampton and Sherstyuk (2012). In Phase 2, the capacities are greater than those of a Bertrand equilibrium with two private firms; this is possible because SOEs have stronger incentives to increase their capacities and sales.

Because our focus is the effects of increases in subsidies on capacities, prices, sales, and profits, we investigate the effects on market variables by using the Wilcoxon Signed-Rank Test. The results, which are P-values, are shown in Table 2 for SS3 (Sessions 4, 5, and 8) and CS3 (Sessions 6, 7, and 9). As long as we focus on market variables, there seems to be no common differences between the values of Phases 1 and 2 across sessions. For example, when we focus on SS3, all variables of both phases in Session 4 are significantly different from each other, while there are no significant differences in each variable between both phases in Sessions 5 and 8. On the other hand, when we focus on CS3, there is a significant difference in profits between both phases in Session 6, while there are no clear differences in profits in Sessions 7 and 9.

3.2 Variables for Private Firms and SOEs

The result that indicates that increases in production/capacity subsidies may not influence market variables does not necessarily mean that there is no effect on the behavior of either private firms or SOEs. They may change their decision-making according to policy changes. Thus, in this subsection, we investigate capacities, prices, sales, idle capacities, and profits for both private firms and SOEs separately.

First, we examine private firms. The results are shown in Table 3a. Overall, when focusing on capacities and prices, those values are between the Cournot and Bertrand equilibria in a

two-private-firm-duopoly case. However, when focusing on sales, it seems to be almost equivalent to the sales in the Cournot equilibrium.

Focusing on the changes in the averages between two phases, a clear contrast between two policies is observed. In the case of a production subsidy, capacities, sales, and idle capacities increase while prices and profits decrease. These facts imply that competition becomes more severe with an increase in a production subsidy. Private firms expect that rival SOEs will increase their sales more aggressively, and they respond to this policy change by lowering their prices. An interesting point is that this change in the second (price setting) stage makes private firms increase their capacities in the first stage. Private firms may use capacity building as a threat. On the other hand, interestingly, the capacities and sales of private firms decrease and prices and profits increase with an increase in capacity subsidy. Idle capacities also decrease. It is likely that private firms expect that rival SOEs increase their capacities aggressively because this type of subsidy directly encourages capacity building of SOEs, and, accordingly, the private firms decrease their capacities in response to this change in the situation. We investigate the situation more precisely using the Wilcoxon Signed-Rank Test. The analysis, shown in Table 3b, reveals the following results.

Result 1. *In response to an increase in a production subsidy, private firms lower their prices. Their profits decrease on average. On the other hand, in response to an increase in capacity subsidy, private firms decrease capacities. Idle capacities decrease as a result, on average.*

The Wilcoxon Signed-Rank Test results indicate that a change in subsidy that directly influences the first stage variable changes the decision making in the first stage, while a change in subsidy that directly influences the second stage mainly changes the decision making in the second stage.

Second, we examine SOEs. The results are shown in Table 4a. Overall, when focusing on sales and prices, it is obvious that those values are between the Cournot and Bertrand equilibria in a two-private-firm-duopoly case. However, when focusing on capacities, except for Phase 1 in the case of a production subsidy, the amounts are greater than those in the half of sales in the Bertrand equilibrium.

The changes, on average, between two phases are different from those for private firms. In the case of a production subsidy, the changes in capacity, price, sales, and profits are similar to those for private firms. However, idle capacities decrease. Considering that subsidized SOEs are incentivized to increase their sales, this result is intuitive. SOEs have incentives to increase their sales given their capacities in the second stage. In the case of capacity subsidy, in contrast to the changes in variables for private firms, SOEs increase capacities and sales, although the increased amounts are smaller than with a production subsidy. Because private firms decrease their capacities and sales, the average price in Phase 2 is higher than that in Phase 1. It is verified that the effects of both types of subsidies on competition structure in the first stage are different from each other. In particular, the Wilcoxon Signed-Rank Test analysis (P-values), shown in Table 4b, reveals the following results.

Result 2. *In response to an increase in a production subsidy, SOEs increase their capacities and sales, and lower their prices. On the other hand, in response to an increase in capacity subsidy, SOEs increase their capacities, while prices do not change, on average.*

Now, let us examine total quantities and compare private firms and SOEs. First, as noted above, the average capacities of SOEs are greater than the half of the Bertrand equilibrium with a two-private-firm-duopoly case. However, total capacities of both private firms and SOEs do not exceed the total supply in the Bertrand equilibrium, on average. Second, the

average prices for both private firms and SOEs increase in the case of a capacity subsidy. This result implies that consumer surplus decreases due to an increase in capacity subsidy. Third, although the directions of the changes in variables in the case of a production subsidy are the same for both private firms and SOEs, the increased/decreased amounts are greater for SOEs than for private firms. Considering that SOEs are subsidized, this difference is intuitive. Fourth, the average profits of SOEs increase due to an increase in capacity subsidy. Because the objective of SOEs is different from profit maximization, this result is interesting. SOEs have an incentive to increase their capacities and, accordingly, the increased amount of average profits is smaller than that of private firms. However, as described above, private firms decrease their capacities by larger amounts on average, which prevents the market price from declining. Consequently, even though SOEs increase their capacities and sales in response to an increase in capacity subsidy, their profits increase.

3.3 Surpluses

Now, let us investigate the effects of subsidy on social and domestic surpluses. Social surplus is defined as the sum of consumer surplus and the profits of both a private firm and an SOE. Because subsidy is a kind of income redistribution, we do not describe it explicitly. On the other hand, domestic surplus is defined as the sum of consumer surplus and the profits of an SOE.[9] In the real situation, subsidies to domestic SOEs were/are often international issues. In such cases, the point is that the condition for competition is unfavorable to foreign private firms. Moreover, it is sometimes argued that subsidized SOEs influence the international market, which decreases the profits of private firms. Thus, it is natural to consider not only social surplus but also domestic surplus, as defined above.

[9] There is another possible definition of surplus, which includes the utility of the manager of an SOE. However, we focus not on subjective values but on objective values in this subsection.

The results are shown in Tables 5a and 5b. Focusing on averages, both social and domestic surpluses increase in the case of a production subsidy, while they decrease in the case of a capacity subsidy. Because the average prices of both private firms and SOEs decrease in response to an increase in production subsidy in the former case, consumer surplus increases. Thus, the distortion caused by imperfect competition is mitigated and, accordingly, both surpluses increase. On the other hand, the average total capacities and sales decrease, and, accordingly, the average price increases in the latter case. Thus, the distortion caused by imperfect competition becomes more serious, and surpluses are decreased.

Result 3. *Both social and domestic surpluses increase in the case of a production subsidy and decrease in the case of a capacity subsidy.*

Let us also consider a third-market model, which is not very unusual in the field of international trade theory. Both a domestic SOE and a foreign private firm enter a third market. Only the profits of SOEs are included in domestic surplus. In this case, according to Tables 3a and 4a, domestic surpluses decrease in the case of a production subsidy and increase in the case of a capacity subsidy.

3.4 Individual Behavior

In this subsection, we delve into the individual behavior of the subjects to examine if there are any differences in the effects of policy changes. Because the subjects/firms determined their capacities and prices, we also adopt these two variables as dependent variables.

First, we focus on capacity choices. The data have the characteristics of panel data; therefore, we estimate the following equation by using panel data analysis.

$$Capacity_t = \alpha + \beta_1 partner\_capa_{t-1} + \beta_2 partner\_price_{t-1} + \beta_3 idl\_capacity_{t-1} + \beta_4 reward_{t-1} + \beta_5 sum\_reward_t + \beta_6 risk + \beta_7 private + \varepsilon$$

We adopt seven independent variables. *Pre-partner-capa (partner_capa_t-1)* is the capacity chosen by the partner (the rival firm) in the previous round, and *pre-partner-price (partner_price_t-1)* is the price chosen by the partner in the previous round. These two variables capture if and how subjects respond to the partner's decision making. *Pre-idle (idle_t-1)* is the amount of a subject's own idle capacity in the previous round. It is possible that the larger the amount of idle capacity in the previous round, the less aggressive a subject becomes when determining her/his capacity in the present round. *Pre-reward (reward_t-1)* is the reward that is gained by a subject in the previous round, and *sum-reward (sum_reward_t)* is the sum of the reward that is gained by a subject from the first round through the previous round. There are two possibilities in the direction of the effects of these variables. The marginal utility from additional income decreases in general. When a subject considers that s/he has already gained a lot of rewards, s/he may have weaker incentive to earn rewards. On the other hand, a subject may consider that if s/he loses the competition against the partner in the present round, s/he will still possess enough rewards. When the subject perceives the situation this way, s/he may become more aggressive than in the past. *Risk* measures the degree of risk averting: the greater this variable, the more risk averse a subject is. *Private* is a dummy variable, which is equal to 1 when a subject plays the role of a private firm and equal to 0 when a subject plays the role of an SOE.

The results for the case of the production subsidy are shown in Table 6. We conduct the estimations for Phases 1 and 2 separately. Hausman and F-tests indicate that fixed-effects models are supported for all estimations. However, because the personal/firm attributes (*risk*

and *private*) are considered important, we show the results of pooled-cross-section, fixed-effects-model, and random-effects-model estimations.

For Phase 1, the coefficients of the *pre-idle* and *pre-reward* are significant and positive for all of three estimations. The effect of *pre-idle* is counter-intuitive. The possible reason for this result is that a subject who had a lot of idle capacities in the previous round considers that s/he is losing the competition with the partner. Therefore, s/he becomes more aggressive in the present round to beat the rival. The effect of *pre-reward* can be interpreted that the larger amount of rewards a subject possesses, the more aggressive s/he becomes when determining her/his capacity. The significant result on the coefficient of *sum-reward* of the fixed-effects-model estimation also support this behavior of the subjects. For Phase 2, we do not find any significant results that are common for all three estimations, although the signs of the coefficients are almost consistent with those for Phase 1.

The results for the case of a capacity subsidy is shown in Table 7. Although the signs of the coefficients are almost the same as those for the case of production subsidy, the significant results for Phase 1 are different between two types of subsidies. In the case of capacity subsidy, the coefficient of *pre-partner-capa* is significant and positive. This result indicates that conditional cooperation holds, meaning that if the partner decreases the capacity, a subject responds by decreasing her/his capacity, increasing the profits of both subjects.[10] On the other hand, a subject acts non-cooperatively if the partner acts non-cooperatively. Note that the same result is obtained from the pooled-cross section and fixed-effects-model estimations for the case of a production subsidy. For Phase 2, interestingly, no signs of conditional cooperation are observed.

Overall, R-squared values for the fixed-effects-model estimations are very small. The personal/firm attributes clearly influence capacity choices. In particular, the role of a subject

[10] This result does not indicate strategic substitutes.

as a private firm or an SOE significantly influences capacity choices. Thus, let us next focus on the values of the coefficients of *private*. The results are similar for both types of subsidies: (i) the coefficients are significant and negative, and (ii) the values after subsidy increases are greater than those before subsidy increases. The second result also indicates that policy changes also significantly influence capacity choices.

Next, we focus on the price setting. We estimate the following equation.

$$Price_t = \alpha + \beta_1 capacity_t + \beta_2 group\_capacity_t + \beta_3 partner\_price_{t-1} + \beta_4 idle\_capacity_{t-1} + \beta_5 reward_{t-1} + \beta_6 sum\_reward_t + \beta_7 risk + \beta_8 private + \varepsilon$$

When subjects choose prices, they have information about their capacities and those of the partners. Thus, the capacity chosen in the previous round by partners is not chosen as an independent variable. Instead, we adopt two variables on capacities: c*apa (capacity_t),*which is a subject's own capacity in the present round, and *group-capa (group_capacity_t)*, which that is the total capacity of both subjects in a market in the present round. The effect of a capacity increase on the price setting may be different when a subject's own capacity changes than when her/his partner's capacity changes. Thus, we introduce two types of variables on capacities.

The results for the case of production subsidy and capacity subsidy are shown in Tables 8 and 9, respectively. First, let us examine the effects of changes in capacities. When focusing on the coefficients of *group-capa*, all coefficients are significant and negative for both phases in both cases of subsidies. This result is intuitive and reveals that subjects understand that the

total sales and equilibrium prices are negatively correlated.[11] However, there is an important difference in the size of the effect of *group-capa* between the cases for both types of subsidies. In the case of a production subsidy, the sizes of the coefficients are almost the same for both phases. On the other hand, the size of the coefficients for Phase 2 is greater than that for Phase 1 in the case of a capacity subsidy. Moreover, the coefficients of *capa* is significant and negative in the case of a production subsidy while, surprisingly, the coefficient is significant and positive in the case of a capacity subsidy. It is also verified from the coefficients of these two variables in Phase 2 that (i) a price decrease set by a subject in response to an increase in her/his own capacity is almost the same between types of subsidies, while (ii) a price decrease in response to an increase in the partner's capacity is much greater in the case of capacity subsidy than in the case of production subsidy. These results imply that subjects respond to partners' decisions more aggressively in the case of a capacity subsidy than in the case of production subsidy. Because private firms decrease their capacities in the first stage when a capacity subsidy is provided to SOEs, they have a strong incentive to prevent their capacities from being idle in Phase 2, in particular.

To interpret the difference, we also look at the coefficients of other variables. The coefficients of *pre-partner-price* in the case of production subsidy are significant and positive in Phase 1, which implies that conditional cooperation holds. A subject responds to an increase in the partner's price in the previous round by increasing her/his capacity in the present round. However, the result of the fixed-effects-model estimation is not significant in Phase 2. Although the results are significant for the other two estimations, the sizes are smaller in Phase 2 than in Phase 1. The situation in the case of a capacity subsidy was different. The coefficients

[11] It may be obvious for students of department of economics and business school as far as they are sitting in the lecture room. However, the instruction is a little complicated because they make decisions twice: capacity and price. Moreover, students for other departments are sometimes unfamiliar with this relationship. Thus, this point is important in terms of experimental analysis.

of *pre-partner-price* were insignificant for all estimations in Phase 1, while those of the pooled-cross-section and random-effects-model estimations were significant and positive in Phase 2. The sizes of those coefficients were clearly larger in Phase 2 than in Phase 1. Thus, a subject responded to an increase in the partner's price in the previous round by increasing her/his capacity in the present round in Phase 2. In total, it can be said that a capacity subsidy strengthens conditionally cooperative behavior, while a production subsidy weakens the behavior. Because the total capacities increase in the case of a production subsidy in Phase 2, it is natural that the subjects act non-cooperatively.

3.5 Additional Treatments

In this subsection, we examine the results of additional treatments. Because the sample sizes are relatively small for these additional treatments, we focus only on the averages. The average capacities, prices, sales, profits, and idle capacities for private firms and SOEs are shown in Tables 10a and 10b, respectively. Those values in Tables 3 and 4 are the basis of comparison. Overall, the results depend not on the starting level of the production subsidy but on the absolute level.

As far as capacities of private firms, there are no large differences between treatments. However, the direction of the change in capacities and sales of private firms in SS5 and SS9 caused by an increase in the production subsidy is different from the direction in SS1 and SS3. Capacities and sales in Phase 2 are a little smaller than those in Phase 1. The possible reason is that SOEs are more aggressive in Phase 2 in SS5 and SS9 than in SS1 and SS3, so private firms decrease their capacities. On the other hand, the capacities of the SOEs in Phase 1 in SS9 are greater than those in the other treatments. It is possible that there is a threshold: SOEs have a stronger incentive to increase their capacities when subsidy exceeds the threshold. Similar results are obtained for sales. The increased amounts of capacities and sales in

response to an increase in production subsidy seem to depend not on the increased amounts of subsidies but on the fact that subsidies are increased or the absolute level of subsidies.

Prices in these additional treatments are not different from those in SS3. However, as long as we focus on the additional treatments, the amount of subsidy influences the price settings of both private firms and SOEs. There is no clear difference in prices between SS1 and SS5. On the other hand, prices in SS9 are clearly lower than those in the other treatments. Similar results are obtained for profits. The profits of both private firms and SOEs in SS9 are clearly smaller than those in the other treatments, including SS3. In SS9, competition between a private firm and an SOE is severe and, accordingly, prices are low and profits are small.

Finally, the result for idle capacities of private firms is interesting. It is likely that the larger the amount of production subsidy, the greater the amount of idle capacities. Because private firms are not subsidized, the lower limit of price for them is 20. On the other hand, even if SOEs set their prices lower than 20, they may gain positive rewards. Thus, the condition of competition is favorable for SOEs in the second stage, and private firms tend to have larger amounts of idle capacities compared with SOEs.

4. Discussion

The examination of the results of the experiment leads to implications for economic research and the political arena, as discussed in this section.

First, it is interesting that the effects of a production subsidy on total supply and surpluses are different from those of capacity subsidy. The main reason for this difference is the behavior of private firms in choosing capacities. Although the behavior of price setting is different depending on the types of subsidies, the difference in the behavior in the first stage dominates the difference in the behavior in the second stage in terms of the effects on surpluses. Because a capacity subsidy directly encourages capacity building of SOEs, it is a credible threat in the

first stage. Therefore, private firms expect that rival firms (SOEs) will certainly increase their capacities due to an increase in the capacity subsidy and, accordingly, they decrease their capacities to avoid drastic decreases in prices and profits due to severe competition.

In the case of production subsidy, this situation arises in the second stage because the production subsidy directly influences the price-setting behavior of SOEs. Private firms become less aggressive when choosing their prices after production subsidy increases. On the other hand, decreases in capacities of private firms cannot be observed. Thus, the difference in the behavior of private firms in the first stage gives rise to the opposite results in the cases of two types of subsidies.

We also obtained important policy implications. The first point is that even a small amount of subsidy may influence the variables of both private firms and SOEs drastically. For example, focusing again on the behavior of SOEs in SS3 (Table 4a), the increased amount of subsidy in the objective function of the SOEs is equivalent to a decrease in the marginal cost by 4.29. If we consider a case in which all capacities are used for production and both firms compete with each other in quantity, the equilibrium capacity for an SOE increases by 2.86, theoretically. However, according to the result, the average sales increases by more than 10 units (from 61.394 to 71.635). Moreover, the average sales of private firms also increase, even though the marginal sales cost is higher after an increase in the SOEs' production subsidy than before the increase. Because the experiment results indicate that the production subsidy in SS3 increases social and domestic surpluses, this subsidy seems to be a desirable policy. However, it is difficult to know the appropriate amount of production/capacity subsidy to apply. Moreover, it is likely that subsidies are provided excessively for political reasons. In such a case, when considering the possibility of drastic changes in capacities and prices, these types of subsidies should not be allowed easily.

Second, the profits of private firms always decrease in the case of a production subsidy,

and an increase in subsidy makes an unfavorable situation for private firms more serious. Consider a situation in which SOEs are domestic firms and private firms are foreign firms. Production subsidies for SOEs is then likely to causes an international dispute among trading countries. Thus, in terms of free and fair competition, production subsidies for SOEs should be permitted under strict conditions.

Third, the effect of a capacity subsidy is likely to be opposite to the effect of production subsidy. If the competition structure does not change, capacity subsidy is more detrimental to profits and surplus because managers of SOEs gain from increases in capacities even if those capacities are not used for production. They have incentives to increase their capacities, which is likely to lead to an increase in idle capacity. If the competition for capacity building in the first stage or price competition in the second stage becomes severe due to an increase in capacity subsidy, idle capacities of private firms also increase. However, the experiment results indicate the opposite situation: idle capacities of SOEs do not change and those of private firms significantly decrease on average. Moreover, as long as the focus is on the average profit, the increased amount for private firms is greater than that for SOEs. Thus, a capacity subsidy can be less harmful to profits than a production subsidy as long as the amounts of subsidies are not very large. However, this situation arises because private firms decrease their capacities in response to increases in expected capacities of SOEs. On the other hand, if the amount of capacity subsidy is large, the situation may also be similar to that of production subsidy.[12] Consequently, even if the subsidy is provided, the type and volume should be carefully examined. For example, when the amount of subsidy is small, a production subsidy is more desirable than a capacity subsidy, because the positive effect on surpluses is likely to dominate the negative effect on inefficiency like an increase in idle capacities.

[12] We did not have enough budget this time to examine the volume effect of capacity subsidy. However, this point is interesting. It is a future task to carry out in additional sessions.

However, when the amount of subsidy is relatively large, a capacity subsidy is more desirable than a production subsidy, because it is less likely that a capacity subsidy will trigger drastic price decreases.

5. Conclusion

We have experimentally examined whether subsidies for an SOE changes the behavior of either a private firm or the SOE under mixed duopoly. We conducted a series of laboratory experiments adopting a two-stage capacity-price decision-making duopoly setting. We adopted two treatments in terms of types of subsidies: one is a subsidy for production/sales and the other is a subsidy for capacity building.

We obtained several interesting results. For example, a production subsidy increases the capacities of both private firms and SOEs and, accordingly, the prices of both types of firms decrease. On the other hand, a capacity subsidy decreases the capacities of private firms, while those of SOEs increase. We also found that both social and domestic surpluses increase in the case of a production subsidy, but decrease in the case of capacity subsidy. In the former case, the severe competition mitigates the distortion caused by imperfect competition. Moreover, firm/personal attributes significantly influence capacity choices. In particular, the participant's role as a private firm or an SOE significantly influences capacity choices. In summary, the effects on capacities, prices, sales, idle capacities, and profits depend on the type of subsidy.

The fact that even a small amount of subsidy may substantially influence the variables of both private firms and SOEs has important policy implications. In some cases, private firms compete with SOEs in very unfavorable situations. In particular, when foreign private firms enter the domestic market, even a small amount of subsidy for domestic SOEs may cause an international dispute. In such a case, the use of subsidies for SOEs should be strictly restricted. In addition to theoretical analyses in the literature, we believe that we have provided

experimental evidence of the effect of subsidies on the situation of mixed duopoly, including changes in the competition structure and strategic behavior.

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Table1. Experimental Sessions

	Session ID	Date	Number of Subjects	Number of Markets	Rounds
Production Subsidy	1	22-Jun-17	10	5	18
SS9	2	22-Jun-17	10	5	18
Production Subsidy	3	23-Jun-17	10	5	17
SS1					
Production Subsidy	4	29-Jun-17	12	6	17
SS3	5	29-Jun-17	12	6	18
	8	6-Jul-17	12	6	18
Production Subsidy	10	7-Jul-17	10	5	18
SS5					
Capacity Subsidy	6	30-Jun-17	8	4	18
CS3	7	30-Jun-17	12	6	18
	9	6-Jul-17	10	5	18

Table 2.Wilcoxon Signed-Ranks Test Between Phases for Market Values (P-Values)

Session ID	Capacity	Price	Sales	Profits
4	0.040	7.042e-05	0.051	0.021
5	0.475	0.157	0.400	0.300
8	0.172	0.022	0.340	0.438
6	0.399	0.101	0.430	0.077
7	0.582	0.554	<2.2e-16	0.791
9	0.438	0.918	0.956	0.908

Table 3a. Average and Standard Deviations of Private Firm Variables

		Phase 1		Phase 2	
		Ave	StDev	Ave	StDev
Production Subsidy	Capacity	68.128	26.719	71.27	27.371
	Price	38.368	10.444	34.635	9.617
	Sales	53.776	28.094	55.579	27.167
	Profits	531.832	899.039	377.817	955.242
	Idle	14.352	29.18	15.69	31.666
Capacity Subsidy	Capacity	70.611	27.885	61.712	22.05
	Price	35.968	12.008	36.221	9.405
	Sales	55.011	24.697	51.587	18.853
	Profits	402.211	800.947	567.923	682.205
	Idle	16	26.289	10.125	19.9

Table 3b.Wilcoxon Signed-Ranks Test for Private Firm Variables Between Phases (P-Values)

Treatment	Capacity	Price	Sales	Idle	Profits
Production Subsidy	0.498	0.001	0.281	0.724	0.0096
Capacity Subsidy	0.047	0.857	0.487	0.035	0.211

Table 4a. Average and Standard Deviations of SOE Variables

		Phase 1		Phase 2	
		Ave	StDev	Ave	StDev
Production Subsidy	Capacity	75.096	24.836	83.627	27.506
	Price	38.282	10.152	33.611	9.79
	Sales	61.394	27.327	71.635	30.629
	Profits	696.979	873.746	549.032	931.046
	Idle	12.752	21.925	11.992	21.943
Capacity Subsidy	Capacity	80.137	25.445	83.596	25.415
	Price	35.768	10.113	37.692	11.098
	Sales	66.811	25.396	69	23.544
	Profits	643.905	836.643	755.096	738.832
	Idle	14.073	22.834	14.596	19.857

Table 4b.Wilcoxon Signed-Ranks Test for SOE Variables Between Phases (P-Values)

Treatment	Capacity	Price	Sales	Idle
Production Subsidy	0.0005	9.585e-08	7.574e-05	0.991
Capacity Subsidy	0.082	0.537	0.484	0.503

Table 5a. Aerages and Standard Deviations of Surpluses

		Phase	Ave	StDev
Production Subsidy	Surplus	1	5835.333	469.025
		2	6032.732	350.542
	Domestic Surplus	1	5288.728	1086.989
		2	5654.915	1113.291
Capacity Subsidy	Surplus	1	5916.408	459.342
		2	5903.642	438.661
	Domestic Surplus	1	5514.197	1022.783
		2	5335.719	984.325

Table 5b.Wilcoxon Signed-Ranks Test for Surpluses Between Phases (P-Values)

Treatment	Surplus	Domestic Surplus
Production Subsidy	0.0005	0.006
Capacity Subsidy	2.003e-06	0.663

Table 6. Capacity Choice: Production Subsidy

	Phase 1 Pooled	Phase 1 Fixed	Phase 1 Random	Phase 2 Pooled	Phase 2 Fixed	Phase 2 Random
Pre-partner-capa	0.284***	0.047	0.196***	-0.016	0.090	0.045
	(0.066)	(0.068)	(0.066)	(0.095)	(0.113)	(0.100)
Pre-partner-price	-0.171	-0.113	-0.099	-0.568**	-0.074	-0.309
	(0.120)	(0.110)	(0.114)	(0.221)	(0.251)	(0.228)
Pre-idle	0.377***	0.141*	0.252***	0.068	-0.010	0.012
	(0.088)	(0.082)	(0.084)	(0.090)	(0.091)	(0.869)
Pre-reward	0.014***	0.009***	0.011***	0.004	0.002	0.003
	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)	(0.004)
Sum-reward	-0.002***	0.001*	-0.001***	-0.002***	-0.0005	-0.002***
	(0.0004)	(0.0005)	(0.0004)	(0.0002)	(0.0008)	(0.0002)
risk	-0.562		-0.474	-0.900		-0.881
	(0.585)		(0.933)	(-0.630)		(0.962)
private	-10.207***		-9.024**	-15.183***		-16.238***
	(2.728)		(4.395)	(3.014)		(4.595)
constant	61.327***	61.788***	63.219***	121.090***	75.814***	108.731***
	(9.262)	(7.953)	(10.463)	(13.507)	(16.880)	(15.400)
Observations	314	314	314	238	238	238
Adj R2	0.242			0.364		
Within R2		0.046	0.003		0.007	0.004
Between R2		0.335	0.594		0.414	0.622
Overall R2		0.066	0.244		0.260	0.378
F Value	15.28	2.65		10.35	0.29	
Wald Chi2			26.22			55.81

-The values in the parentheses are standard errors.

-The superscripts ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 7. Capacity Choice: Capacity Subsidy

	Phase 1 Pooled	Phase 1 Fixed	Phase 1 Random	Phase 2 Pooled	Phase 2 Fixed	Phase 2 Random
Pre-partoner-capa	0.264***	0.203**	0.272***	-0.030	0.104	0.022
	(0.083)	(0.083)	(0.080)	(0.127)	(0.127)	(0.124)
Pre-partner-price	-0.062	0.300*	0.138	-0.895***	-0.243	-0.635***
	(0.169)	(0.164)	(0.163)	(0.216)	(0.227)	(0.215)
Pre-idle	0.159	0.031	0.094	0.263**	0.150	0.221*
	(0.114)	(0.115)	(0.112)	(0.127)	(0.127)	(0.124)
Pre-reward	0.006	0.003	0.004	0.014*	0.010	0.013*
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)
Sum-reward	-0.002***	0.000	-0.0014**	-0.001***	-0.0003	-0.001***
	(0.001)	(0.001)	(0.0007)	(0.0003)	(0.0008)	(0.0003)
risk	-0.269		-0.222	-0.057		-0.063
	(0.504)		(0.772)	(0.515)		(0.675)
private	-10.943***		-11.644**	-14.290***		-16.304***
	(3.148)		(4.732)	(3.567)		4.463)
constant	64.826***	45.872***	55.673***	110.433***	68.324***	99.460***
	(10.805)	(10.566)	(11.169)	(15.314)	(16.596)	(15.383)
Observations	245	245	245	208	208	208
Adj R2	0.203			0.278		
Within R2		0.044	0.016		0.015	0.011
Between R2		0.093	0.447		0.381	0.578
Overall R2		0.0003	0.204		0.158	0.295
F Value	9.86	1.93		12.36	0.53	
Wald Chi2			25.10			47.34

-The values in the parentheses are standard errors.

-The superscripts ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 8. Price Setting: Production Subsidy

	Phase 1 Pooled	Phase 1 Fixed	Phase 1 Random	Phase 2 Pooled	Phase 2 Fixed	Phase 2 Random
Capa	-0.014	-0.099**	-0.014	-0.081**	-0.139***	-0.081**
	(0.440)	(0.049)	(0.044)	(0.032)	(0.036)	(0.032)
Group-capa	-0.110***	-0.083**	-0.110***	-0.109***	-0.084***	-0.109***
	(0.028)	(0.033)	(0.028)	(0.021)	(0.022)	(0.021)
Pre-partner-price	0.243***	0.165***	0.243***	0.143**	-0.088	0.143**
	(0.057)	(0.060)	(0.057)	(0.065)	(0.069)	(0.065)
Pre-idle	0.081*	-0.024	0.081*	0.023	-0.070***	0.023
	(0.041)	(0.043)	(0.041)	(0.026)	(0.025)	(0.026)
Pre-reward	0.001	0.0007	0.001	-0.001	-0.003**	-0.001
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Sum-reward	-0.0002	0.0007**	-0.0002	-0.000	-0.0002	-0.000
	(0.0002)	(0.0003)	(0.0002)	(0.000)	(0.0002)	(0.000)
risk	0.009		0.009	0.076		0.076
	(0.276)		(0.276)	(0.188)		(0.188)
private	1.209		1.209	-0.112		-0.112
	(1.312)		(1.312)	(0.963)		(0.963)
constant	44.207***	48.589***	44.207***	52.261***	65.080***	52.261***
	(4.218)	(3.965)	(4.218)	(3.670)	(3.756)	(3.670)
Observations	314	314	314	238	238	238
Adj R2	0.193			0.536		
Within R2		0.172	0.101		0.462	0.382
Between R2		0.214	0.549		0.348	0.736
Overall R2		0.141	0.213		0.412	0.552
F Value	10.35	9.39		35.20	28.02	
Wald Chi2			82.76			281.59

-The values in the parentheses are standard errors.
-The superscripts ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 9. Price Setting: Capacity Subsidy

	Phase 1 Pooled	Phase 1 Fixed	Phase 1 Random	Phase 2 Pooled	Phase 2 Fixed	Phase 2 Random
Capa	0.033	0.014	0.033	0.086***	0.111***	0.086***
	(0.035)	(0.040)	(0.035)	(0.029)	(0.035)	(0.029)
Group-capa	-0.178***	-0.183***	-0.178***	-0.279***	-0.289***	-0.279***
	(0.025)	(0.029)	(0.025)	(0.020)	(0.024)	(0.020)
Pre-partner-price	0.025	-0.002	0.025	0.201***	0.078	0.201***
	(0.061)	(0.070)	(0.061)	(0.064)	(0.070)	(0.064)
Pre-idle	0.116***	0.012	0.116***	0.052*	-0.010	0.052*
	(0.040)	(0.046)	(0.040)	(0.030)	(0.032)	(0.030)
Pre-reward	0.005***	0.002	0.005***	-0.001	-0.0003	-0.001
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Sum-reward	-0.0002	-0.0001	-0.0002	-0.0003***	-0.000	-0.0003***
	(0.0002)	(0.0003)	(0.0002)	(0.0001)	(0.000)	(0.0001)
risk	0.130		0.130	0.036		0.036
	(0.183)		(0.183)	(0.147)		(0.147)
private	0.131		0.131	-0.481		-0.481
	(1.159)		(1.159)	(1.065)		(1.065)
constant	54.863***	61.498***	54.863***	65.860***	68.916***	65.860***
	(3.809)	(4.006)	(3.809)	(3.541)	(3.845)	(3.541)
Observations	245	245	245	208	208	208
Adj R2	0.408			0.642		
Within R2		0.257	0.234		0.574	0.555
Between R2		0.673	0.771		0.716	0.826
Overall R2		0.405	0.427		0.625	0.656
F Value	21.99	12.07			38.57	
Wald Chi2			175.94			379.83

-The values in the parentheses are standard errors.
-The superscripts ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table 10a. Average Variables for Private Firms for Additional Sessions

		SS1		SS5		SS9	
		Phaes 1	Phase 2	Phaes 1	Phase 2	Phaes 1	Phase 2
Production Subsidy	Capacity	66.388	75.848	71.9	71.15	72.826	70.87
	Price	39.02	39.788	41.08	38.225	35	34.174
	Sales	50.694	41.364	56.44	53.8	55.884	51.174
	Profits	463.388	-52.545	625.5	384.5	389.014	207.304
	Idle	15.694	33.471	15.46	17.35	16.942	19.696

Table 10b. Average Variables for SOEs for Additional Sessions

		SS1		SS5		SS9	
		Phaes 1	Phase 2	Phaes 1	Phase 2	Phaes 1	Phase 2
Production Subsidy	Capacity	75.898	89.848	71.14	81	81.29	87.493
	Price	38.939	36.394	40.46	36.1	35.464	32.304
	Sales	65.02	78.182	53.78	67.825	67.333	76.377
	Profits	736.429	711.212	496.76	455.525	445.899	516.754
	Idle	10.878	11.667	17.36	13.175	13.957	11.116

Figure 1: Demand Table

Price	Market Demand	Price	Market Demand
0	200	51	98
1	198	52	96
2	196	53	94
3	194	54	92
4	192	55	90
5	190	56	88
6	188	57	86
7	186	58	84
8	184	59	82
9	182	60	80
10	180	61	78
11	178	62	76
12	176	63	74
13	174	64	72
14	172	65	70
15	170	66	68
16	168	67	66
17	166	68	64
18	164	69	62
19	162	70	60
20	160	71	58
21	158	72	56
22	156	73	54
23	154	74	52
24	152	75	50
25	150	76	48
26	148	77	46
27	146	78	44
28	144	79	42
29	142	80	40
30	140	81	38
31	138	82	36
32	136	83	34
33	134	84	32
34	132	85	30
35	130	86	28
36	128	87	26
37	126	88	24
38	124	89	22
39	122	90	20
40	120	91	18
41	118	92	16
42	116	93	14
43	114	94	12
44	112	95	10
45	110	96	8
46	108	97	6
47	106	98	4
48	104	99	2
49	102	100	0
50	100		

Figure 2: Questions for Risk Preferences

Date: Time:

ID

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
1	①、②、③	JPY 400	①	JPY 680
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
2	①、②、③	JPY 400	①	JPY 750
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
3	①、②、③	JPY 400	①	JPY 830
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
4	①、②、③	JPY 400	①	JPY 930
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
5	①、②、③	JPY 400	①	JPY 1060
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
6	①、②、③	JPY 400	①	JPY 1250
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
7	①、②、③	JPY 400	①	JPY 1500
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
8	①、②、③	JPY 400	①	JPY 1850
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
9	①、②、③	JPY 400	①	JPY 2200
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	ChoiceA		ChoiceB	
	Ball	Prize	Ball	Prize
10	①、②、③	JPY 400	①	JPY 3000
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

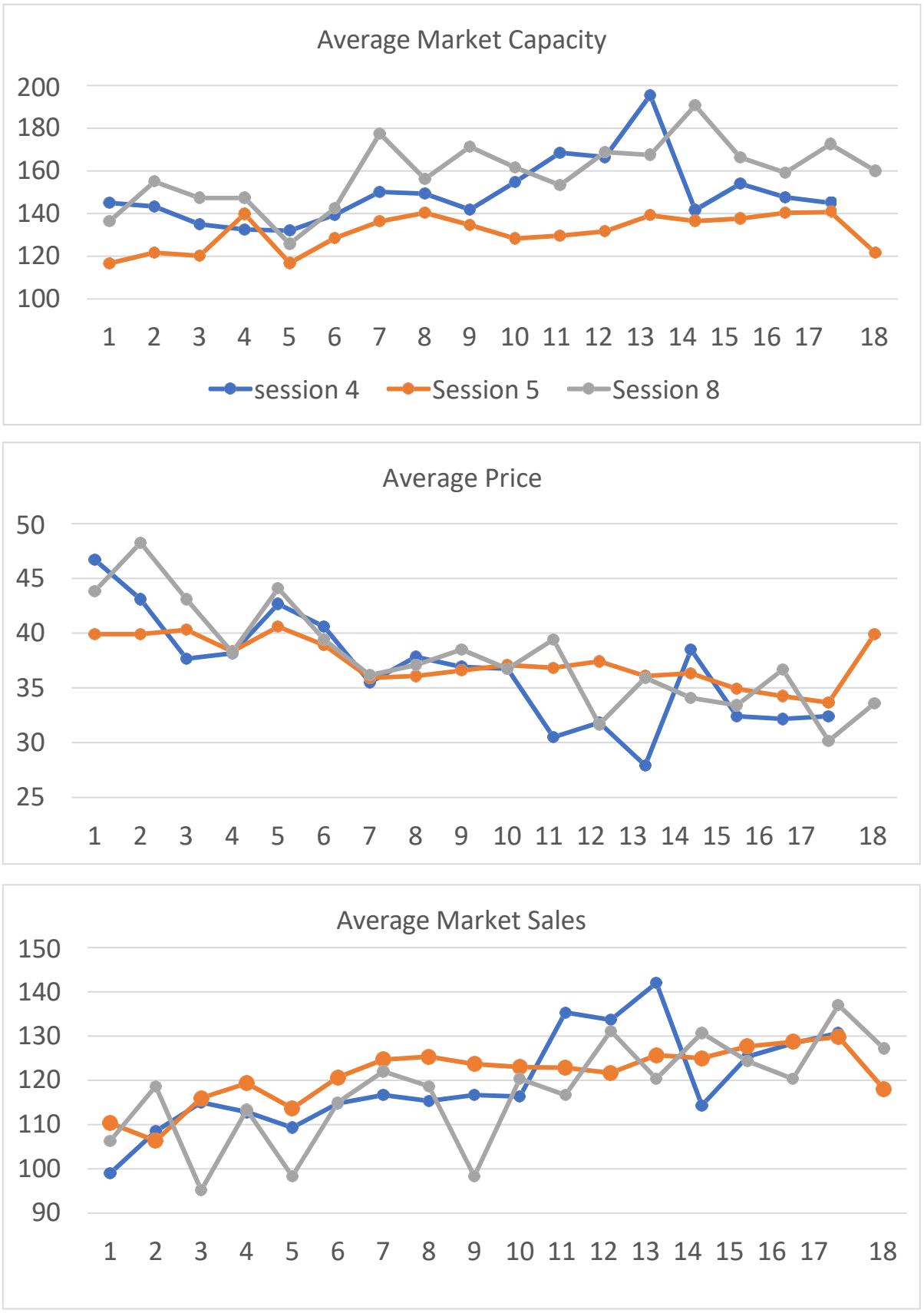

Figure 3. Market Values of SS3 Treatments
(Production subsidy after round 10)

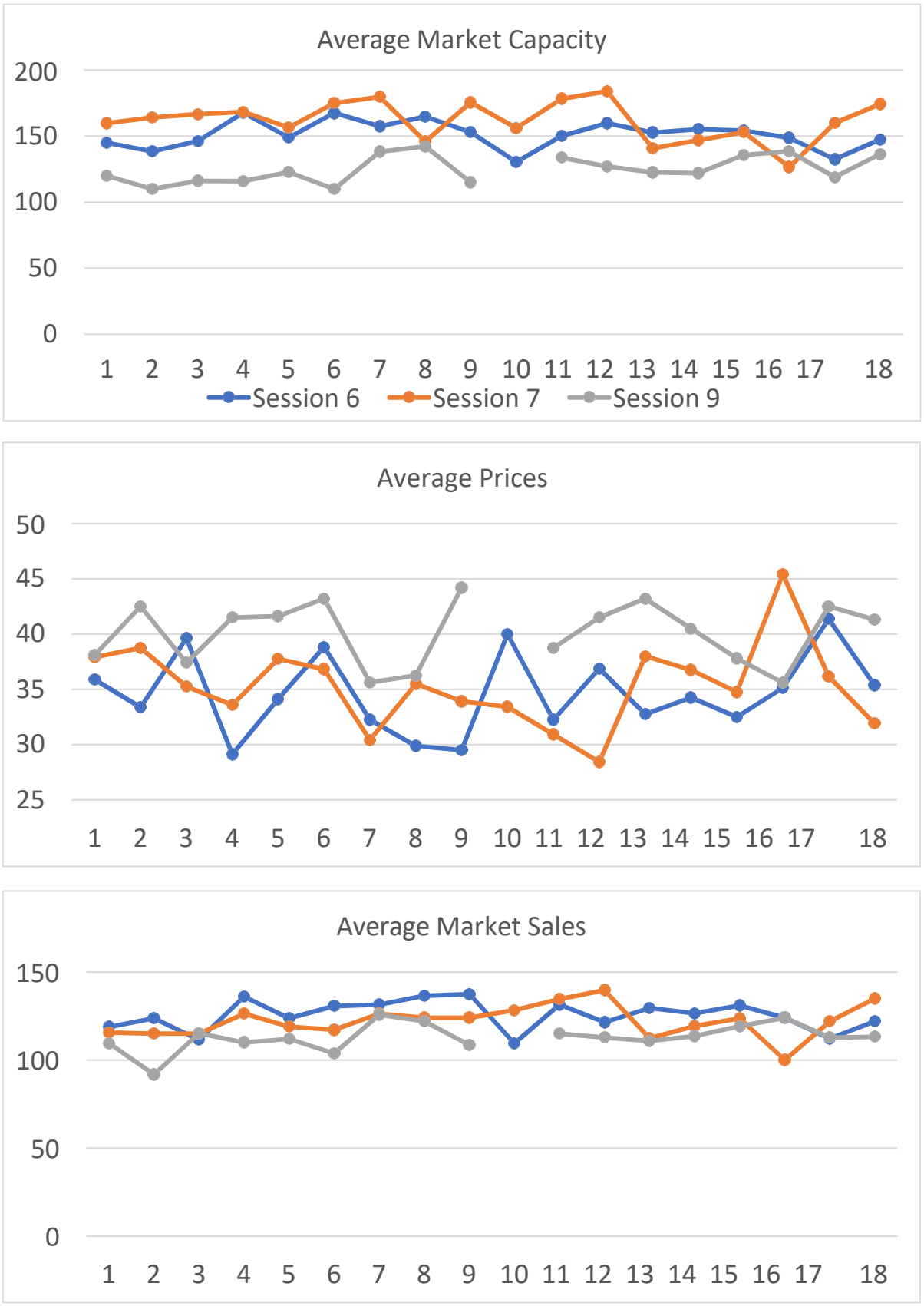

Figure 4. Market Values of SC3 Treatments
(Capacity subsidy after round 10)