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Public announcements of violators and compliance behaviors under a tradable permits scheme: Experimental analysis of market trading

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Abstract

If some market participants break market rules, market efficiency deteriorates. Conducting laboratory experiments, we examine the effects of public announcements and fines on violators' behavior. Two types of announcements are examined in our paper: announcements of violators' names and announcements of their IDs. Although several types of remedial measures against market violations have been implemented everywhere, the extent to which announcements suppress violations is not clear. Our findings are fourfold. First, even when the amount of fine is small, fines are the most useful punishment in increasing market compliance. This finding may reflect a social norm involved with paying a fine. Second, publicly announcing the names and IDs of violators is helpful in suppressing violations. Market compliance can be ensured by not only monetary interventions, such as fines, but also by information disclosure, such as via public announcements. Third, it is important for authorities to understand the content that is publicly announced. Fourth, when implementing the public announcement of violators' names, market transaction volumes and prices decrease and increase, respectively. This finding implies that the announcement of names may have an influence on market welfare.

Keywords: market compliance, punishment, public announcement, and fine

1. Introduction

In the real economy, market rules and regulations are frequently imposed by public or private authorities to ensure the benefits of market-based mechanisms. The tangible content of rules depends on what goods are trading in the market. For example, insider trading and constructing a house with asbestos are prohibited in the stock and housing markets, respectively. If someone breaks such market rules and if administrative authorities are not aware of violations, market efficiency and fairness are deteriorated. Therefore, many researchers are concerned with disciplining market participants and suppressing their violations.

A number of studies have theoretically and empirically examined the relationships among public monitoring, punishment and market participants' (i.e., individuals' or organizations') compliance behaviors based on rational expectation theory. If the expected cost of a violation punishment multiplied by the detected probability from monitoring is higher than the expected benefit of the violation, rational market participants do not break a market rule (Cooter and Ulen, 2012). However, it may be difficult for authorities to set an adequate amount of fines in practical and law matters. In the context of tax compliance, the sizes of fines are too low to suppress violations in many countries (Feld and Frey, 2007). Additionally, authorities may face difficulties investing monitoring systems, such as the number of market supervisors, due to budget constraints. Therefore, it is expected that excess market violations will be observed.

On the contrary, previous studies have shown that individuals and organizations comply with market rules even when poor punishment and monitoring systems are imposed (Cason and Grangadharan, 2006). This finding suggests that not only external economic factors, such as fines but also internal psychological factors influence compliance behaviors, which is ignored by traditional rational expectation theory (Hofmann et al., 2008)[4]. For example, violations may be suppressed by trust in authorities (Kaplanoglou and Rapanos, 2015) and social norms such as reputation (Teraji, 2013), peer effects (Wakolbinger and Haigner, 2009) and framing effects in punishment (Kurz et al., 2014).[5] The literature shows the complex mechanisms of decision-making processes on compliance with rules.

Another important instrument to prevent violations is ignored in the literature: the public announcement of violators' names. For example, organizations that break the rules stipulated by the Act against Delay in Payment of Subcontact Proceeds, Etc. to Subcontractors in Japan are publicly

[4] Hofmann et al. (2008) is an excellent review paper about tax compliance from the viewpoint of psychology.

[5] In psychology, the trust and framing effects are classified into intrinsic motivation for compliance because these psychological factors are based on private preferences. Reputation and peer effects are recognized as effects of image motivation. Fines and rewards are types of extrinsic motivation (Ariely et al., 2009).

announced. Such a public announcement is a social sanction. Therefore, this paper proposes a third avenue that is different from previous studies. Conducting laboratory experiments on a virtual market where tradable permits (normal goods) are addressed, we examine the effects of public announcements of violators and fines on their behaviors.

Public announcements may prevent the violation of market rules and regulations because they are non-monetary social sanctions (Masclet et al., 2003). Suppose that a person breaks market rules where public announcements of violators are implemented. She may experience a feeling of shame regarding her violation because public announcements enable other market participants to recognize her as a violator. In the case of organizations, the announcement may tarnish their reputation among their business partners, damaging their reputation for corporate social responsibility. Public announcements are considered to play a role in suppressing violations (e.g., Japanese Legislative Bureau House of Councilors, 1997).

However, public announcements may not always suppress violations. They may induce undesirable effects, i.e., increases in violations. Most market participants do not usually see who rule-violators are and to what extent they break rules unless public announcement are imposed. On the contrary, if announcements are implemented, all participants can identify violators and the magnitudes of their violations. Suppose again that some market participants break the rules. A person who usually complies with the rules may be given an excuse to break them, claiming, e.g., "I also break the rule because he breaks it." This is a negative effect that occurs when participants resolve asymmetric information on violations. When the negative effect on compliance behaviors exceeds the positive effect, such as stimulating individual shame and framing effects in punishment, public announcements promote violations. Therefore, the overall effects of this instrument on compliance behaviors cannot be theoretically predetermined.

It is important to examine the effects of public announcements because they are frequently implemented in the world. This is one of the first papers to contribute to the discussion of the public announcement of violators as a punishment system. Although normal goods are traded in our experiment, the policy implications derived from our experimental results may be applied to public goods markets, such as emissions trading markets. Differently from normal goods markets, in emissions trading markets (e.g., EU-ETS), violations cause not only market inefficiency but also harmful non-invertible consequences for the environment. Therefore, by examining the effects of public announcements on violations, our paper potentially also contributes to the literature on emissions trading schemes with an experimental approach (e.g., Stranlund and Dhanda, 1999; Murphy and Stranlund, 2006; Cason and Gangadharan, 2006).

The brief summary of our experiment is as follows. We conducted 12 laboratory experiments (sessions) at computer rooms in the Takasaki City University of Economics. We drew up three punishments in the experiment: fines, public announcements of violators' names and public

announcements of their IDs. Considering all combinations of punishments, 6 treatments (2 sessions under each treatment) were conducted. Twenty subjects participated in each session, and each session consisted of 10 rounds. Each participant took a seat in front of a computer terminal and participated in the virtual trading market created by z-Tree software (Fischbacher, 2007). They were randomly given experimental points (virtual currency), tradable permits (goods), and marginal points for producing non-tradable coupons in every round. The permits gave subjects the right to be exempted from holding coupons;, that is, the permits were equivalent to the coupons. We imposed one common rule: The participants had to possess a designated amount of coupons and permits at the end of each round. If they exceeded this requirement, they could increase their points by selling their extra permits to other subjects in the virtual market. Their rewards were directly converted from their own points. Violation detection was blind but with a fixed probability of 50%. When the described punishments were imposed in a session and violations were detected, the violating subjects were punished. The expected revenue of the subjects was larger than the expected cost (fine or public announcements), implying that our experiment was designed such that every subject could earn more money by breaking the rule. The settings of the experiment were similar to those of Iwata et al. (2014).

Our findings were fourfold. First, even when the amount of the fine was low (participants could gain more rewards when they broke the rules and paid fines), we observed the smallest number of violations among treatments, suggesting that the framing effects in fines were significant for promoting compliance behaviors. Second, we found that both types of public announcements also suppressed violations, implying that the described negative effects involved in the announcement were smaller than the positive effects. Third, it was important for authorities to understand the content that is being publicly announced. Fourth, public announcements of violators' names were implemented, market transaction volumes and prices decreased and increased, respectively. This finding implies that the announcement of names may have an influence on market welfare.

The remainder of this paper is organized as follows. We explain the settings of our laboratory experiments in section 2. Section 3 provides the experimental results and the estimation results of an econometric analysis, where we examine the determinants of individual violations. Section 4 concludes.

2. Laboratory experiment

We conducted laboratory market trading experiments to examine the effects of announcements and fines on compliance behaviors. The laboratory experiments were conducted between 2012 and 2014 (see Table 1). Twelve sessions were performed at computer rooms in the Takasaki City University of Economics. Twenty subjects participated in each session. Differently from most experimental studies, all subjects in our experiments were not university students but ordinary persons sent from an

employment agency. Therefore, university- and status-specific effects were excluded. The subjects earned, on average, 3,000 Japanese yen. At the beginning of each session, we instructed subjects to carefully read the instructions for approximately 10 minutes. We used neutral terminology and words in the instructions. For example, we referred to tradable permits as a "coupon". The instructions are shown in the Appendix.

There were 6 treatment groups, labeled as treatments 0 to 5, as shown in Table 1. Subjects in treatment 0 faced no punishment system, whereas fines and public announcements of violators' IDs were implemented in the treatment 4. Because the announcement of violators' IDs was exclusive to the announcement of violators' names, there were up to 6 combinations of punishment systems. The session dates are also shown in Table 1. We conducted 2 sessions for each treatment. In the table, announcements 1 and 2 stand for the implementation of announcements of violators' IDs and names, respectively. Before subjects were put into laboratory computer rooms, they were given specific personal IDs, which were randomly numbered from 1 to 20. Each subject was seated alone in front of a personal terminal labeled with his or her ID number. Each subject could not directly watch the other subjects but could recognize which seat corresponded to which ID number because the list of all IDs and seat locations was projected on the screen in front of the computer room. The total number of rounds in each session was blind (not announced) but fixed at 10. Each round consisted of 3 stages. Before the real part of experiment, two practice rounds were implemented to ensure subjects' understanding of the experiments[6].

In first stage, subjects could trade the permits with other subjects through a virtual market created by z-Tree software installed at their computer terminals. The market was designed as a double-auction market; i.e., subjects could sell the permits to or buy them from other subjects. Each subject was randomly given experimental points, tradable permits, and marginal points for producing non-tradable coupons. The permits were equivalent to the coupons because they gave subjects the right to be exempted from holding coupons. There was one rule with which the participants had to comply: The sum of coupons and permits was 10 at the end of the round. If a subject were given 4 permits as an initial allocation, he could choose three strategies. The first strategy was to buy an additional 6 permits from the other subjects via the virtual market. (In this case, they did not need to produce coupons.) The second one was to produce an additional 6 coupons with the given experimental points in the second stage. (In this case, they did not buy permits from the other subjects in first stage.) The last one was to employ a mixed strategy with the trade of permits and production of coupons. The initial permits, produced coupons and experimental points were types of short-term endowments; i.e., the remaining permits, coupons and points could not be carried over to next round. The first-stage market was open for 2 minutes. The marginal points for coupons and the initial allocation of permits

[6] In the practice rounds, fines and public announcement were not implemented. In addition, the results of practice rounds are irrelevant to their earnings.

varied across subjects, as shown in Table 2. All subjects were randomly assigned as type 1 (10 subjects) or type 2 (10 subjects). Suppose that a subject were assigned as type 1 (given 5 initial permits). If she could buy additional permits for less than 140, she could earn more points because participants were required to produce 4 coupons. (The marginal point for producing the fourth coupon is 140.) Conversely, if she could sell 1 permit for more than 160, she could also increase her own points. (The marginal point for producing the sixth coupon is 160.). Because their own points are directly converted into their monetary earnings, they can earn more money by efficiently selling or buying the permits in the market, suggesting that the monetary incentive for aggressively trading is implemented in our experiment. For both type 1 and type 2, the initial permits were uniformly fixed at 5 but were blind for subjects. The initial points were 5000 and 4840 for types 1 and 2, respectively, but the points were independent of the market equilibrium (Cason and Gangadharan, 2006). Subjects were not informed about which type they were assigned to; that is, subjects could not recognize the settings of the other subjects. Because the total amount of permits in each round was 100 (=20 × 5), the theoretical competitive price of permit was 120. At the market equilibrium, it was efficient for subjects assigned as types 1 and 2 to sell and buy 3 permits from other subjects.

In the second stage, subjects decided how many coupons they produced, reflecting their own permits after the trading in the first stage. If subjects possessed 7 permits and complied with the rule, they had to produce 3 coupons (= 10 (obligation) – 7 permits). However, they did not absolutely need to comply with the rule. If they possessed 3 permits after trading and intended to break the rule, they could choose to produce 2 coupons. In this case, their amount of coupons and permits took a value of 5, which is below 10, designated by the rule. Extremely, they could choose to produce 0 coupons. In stage 3, the subjects were required to report their own amount of coupons and permits. Even if they did not satisfy the rule (the amount of coupons and permits was less than 10), they could report the amount as 10. Obviously, if any punishment systems were implemented in the experiment, they could earn more points by breaking the rule (submitting a mendacious report).

After stage 3, the administrator (i.e., authors) inspected whether subjects complied with the rule with a fixed probability of 50%. The detection probability was blind. When subjects' violations were detected by the inspection, they were given a punishment. The contents of the punishment depended on the treatments (see Table 1). No punishment was implemented in treatment 0. For treatments 3, 4 and 5, where fines were implemented, violated subjects had to pay a fine according to the magnitude of their violation. The fine was uniformly set to 230 per magnitude among the treatments. Suppose that a subject possessed only 3 coupons and permits and reported that he complied with the rule. The magnitude of his violations is 7 (=10 - 3). Therefore, the violator must pay 1,610 points (= 230×7) if the violation was detected. Remember that the market theoretical price was 120. Even when the fine was implemented, the expected benefit of the violation (i.e., 120) was designed to be larger than its expected cost (i.e., 115 = 230×50%). Therefore, rational subjects could earn more

money by breaking the rule (paying the fine). When the public announcements were implemented, such as in treatments 1, 2, 4 and 5, the violators' names or IDs were publicly announced (see Table 1). If subjects did not feel shame as a result of being perceived by the other subjects as a violator, they opted to break the rule. Because all subjects were hired via an employment agency, they did not know each other before participating in our experiment. In the case of these treatments, the earnings were irrelevant to the violations. Our laboratory experiments can be applied for environment preservation markets, such as an emissions trading scheme when the coupons and permits are read as emissions and allowances.

3. Results of the experiments

3.1. Comparison of violations among treatments

Twelve sessions were conducted to examine the effects of two types of public announcements and fines for violations. Treatment 0 is a baseline control experiment because no punishment system was implemented. Comparing treatments 0 and 1 or 3 and 4, we can identify the effects of the public announcement of violators' IDs. Likewise, the effects of the announcement of violators' name are obtained from the comparison of treatments 0 and 2 or 3 and 5.

Table 1. Implemented punishment systems by treatment

Figure 1 shows the average number of violations per subject by round and treatment. As mentioned in section 2, the maximum and minimum number of violations per subject is 10 and 0, respectively, because the rule required all subjects to possess 10 coupons and permits at the end of each round. The average number of violations per subject ranged from 0 to 3, as shown in the figure. Among treatments, the number of violations in treatments 0 and 1 was found to be large, whereas subjects in treatments 2, 3 and 5 were likely to comply with the rules. This finding may imply that the fines and the public announcements of violators' names suppressed violations, but the public announcement of violators' IDs did not. A similar trend is found in Figure 2, where the average violator rate (i.e., the number of violators divided by 20) is used for the y-axis.

Based on rational expectation theory, in treatment 0, the average number of violations per subject and average violator rate should be 10 and 100%, respectively, because the participants could earn more money under the conditions of our experiment. However, the experimental results do not support this expectation; that is, not all subjects always broke the rule. This finding suggests that social norms such as framing effects in violation work as a deterrent, and their effect on suppressing violations is large. Therefore, it is important for authorities to improve social norms, such as "We should comply with rules," via education, advertisement and other avenues.

Figure 1. Transition of the average number of violations per subject by round and treatment

Figure 2. Transition of the average violator rate by round and treatment

Tables 3 and 4 present the results of Mann-Whitney U test on the average number of violations per subject and the average violator rates with any two treatments. The null hypothesis is that B (row) minus A (column) is equal to zero. For example, the value of the comparison of treatment 0 with 5 is 11.226 in Table 3, implying that the average number of violations per subject in treatment 0 is larger than that in treatment 5 at the 1 percent significance level. These tables show that subjects in treatment 5 were likely to comply with the rule. Therefore, fines and the public announcement of violators' names are significantly useful deterrent measures against violations.

Viewing the results of the comparison of treatments 1 (public announcement: ID) and 2 (public announcement: name), and 4 (public announcement: ID) to 5 (public announcement: name), there are significantly fewer violations in treatments 2 and 5 than in treatments 1 and 4. This finding suggests that the content of public announcements has an influence on individual compliance behaviors. In particular, when authorities intend to implement such public announcements for market compliance, they should select a "direct" name as the content of the announcement instead of an "indirect" ID because individuals may feel more shame from the publication of their names than of their IDs, although other market participants do not know each other. Another reason may be that participants needed to take time (pay opportunity cost) to recognize the connections between them, though the "indirect" IDs were identical to the "direct" names. Ariely et al. (2009) revealed that individual intrinsic motivations for voluntary actions are associated with other persons' recognition of the actions. When a person knows that other persons know that she practices voluntary actions such as charity, her motivation for these actions raises. Our results are in line with the findings of Ariely et al. (2009) because the bad actions are drawn up in this paper.

Table 3. Results of Mann-Whitney U test for the average number of violations per subject

Table 4. Results of Mann-Whitney U test for the average violator rates

3.2. Regression of the market compliances on the punishments

The previous subsections describe the results of market violations without controlling for other factors that potentially influence the compliance behaviors. The price of permits in the virtual market could have had effects on the behaviors (Stranlund and Dhanda, 1999). Participants were expected to break

the rule when the price was high because the expected revenue of the violations increased. Additionally, subjects could break the rule along with the round if learning effects were positively correlated to the compliance behaviors. Therefore, in this subsection, we conduct two econometric analyses where the dependent variables are the average number of violations per subject and the average violator rate, as used in the previous subsection. The sample size in the regressions is 120 (= 12 treatments × 10 rounds).

Table 5 shows the estimation results when the number of violations per subject is employed as a dependent variable. The variables, Fine, Annunce_1 (ID) and Announce_2 (name), are dummies that take values of 1 if the corresponding punishments are implemented. Because the number of market violations per round takes an integer value between 0 and 200 (= 10 × 20), ordinary least squares is not an appropriate estimation method. Therefore, a Poisson regression is employed. Three estimation results are shown in the table. In the first column, we use the mean value of the permit price dealt in the virtual market as an independent variable. Similarly, in the second and third columns, we use the median and mean prices at the last 3 trades in each round, respectively. Although there were 20 subjects in each treatment, several subjects participated in our experiment two or three times. To control for the potential influence of the experience/knowledge on the experiment, we incorporated second and third time dummies.

The fine had a significant deterrent effect on market compliance in all models. This result is similar to that in the previous subsection, implying that the deterrent effects of the fine were robust even if rational expectation theory indicates that the amount of fine is too low to suppress violations. The word "fine" has a social norm implications, such as "We do not want to pay a fine." This finding is consistent with the findings from Cason and Grangadharan (2006).

Although the public announcement of violators' IDs did not significantly reduce violations in the previous nonparametric rank sum test, both public announcements significantly reduced market violations in controlling for the other variables. Comparing the magnitude of the estimated coefficients of the two public announcements, we found that the announcement of violators' names was more helpful in suppressing market violations than the announcement of violator's ID in all models. It is again suggested that the content of announcement is greatly important for market compliance.

The unexpected findings are the signs of the interaction terms of punishments. Both interaction terms are significant and positive. That is, when both the fine and public announcements were simultaneously implemented, the deterrent effects shrunk. This finding may reveal that as more punishments were implemented, it became difficult for subjects to understand the difference between the punishments. In this case, the opportunity cost of accurate understandings may have increased the expected cost of compliance behaviors and then prevented market participants from complying with the market rule.

The robust coefficients of the price show that they were likely to break the rule when the

market price was low. This result is also contrary to rational expectation theory, according to which market price increases the expected benefit of violations and in turn causes more market violations. The detailed argument of the price will be provided in the next subsection.

As for the other variables, round effects were not robustly and significantly observed. The coefficients of the second and third time dummies were also not significant, suggesting that the subjects who participated in our past experiments are less likely to break the rule than the subjects who were first participating in our experiment.

Table 6 presents the estimation results, where the average violator rate is employed as a dependent variable, instead of the average number of violations per subjects. Because the dependent variable takes a value of between 0 and 1, we employ a generalized least squares method to take the characteristics into account (Papke and Wooldridge 1996). The estimated overall trend of each variables is similar to the results in Table 5. Differently from the previous estimation, we find weak deterrence effects of the public announcement of violators' ID. Therefore, it is confirmed again that the "indirect" information on identifying violators is less useful for compliance than "direct" information.

Table 5. Estimation results for the average number of violations per subject

Table 6. Estimation results for the average violator rate

3.3. Discussion on market price and punishments

The econometric analyses show the negative relationship between the market price and violations. In this subsection, we argue the relationship in more detail. The transitions of the average market price are presented in Figure 4. Because the theoretical value of the market price was 120 (see Section 2), the average market price is higher than the theoretical one, except for treatment 0 at round 10. The average price in treatment 0 approaches 120 along with the round, whereas the prices in the other treatments did not. In particular, we find a high price in treatments 2 and 5, where the public announcement of violators' name was implemented. Therefore, the punishment systems may have had an influence on the market price.

Figure 3. Transition of the average market price by round and treatment

When the subjective marginal point (cost) of the permits raised due to the punishment systems, the increase and decrease of the market price and the transaction volume are observed, respectively. To check the probability, we illustrate the total transaction volumes by round and

treatment, as shown in Figure 4. The volume per round ranges between 60 and 160. In all treatments, the transaction volumes are likely to increase along with the round. This finding is explained by the learning effects on our experiment. However, it seems that there is no clear, significant difference in the transaction volumes among treatments.

Figure 4. Transition of transaction volumes by round and treatment

To precisely check the difference, we regress the punishment dummies on the transaction volumes. The estimation results by ordinary least squares are shown in Table 7. The number of observations is also 120, similar to the previous estimations. The second and third columns show the estimation results, where the dependent variable is the transaction volume. The coefficients of public announcements, particularly the announcement of violators' names, are significantly negative, suggesting that subjects under the treatment with announcement of violators' names are not likely to make trades of permits with other subjects. On the contrary, the fine does not influence the transaction volume.

The fourth and fifth columns express the estimation results, where the average prices are used as the dependent variable. The coefficients of public announcements of violators' names are robust and significantly positive, suggesting that the market price is likely to raise in treatments 2 and 5. Therefore, when implementing the public announcement of violators' names as a punishment system, the market trading volume and price decrease and increase, respectively, through the increase in the subjective marginal cost. This finding implies that the announcement has effects on not only the compliance behaviors but also the entire market welfare. The average market price is not found to be robustly related to the fine. Therefore, the effects of fines on market price are limited.

In all estimation models, second and third time dummies are significantly relevant to the transaction volumes and average prices. This finding suggests that past experience in our experiment is associated with such outcomes and that learning effects are one key factor in such a market trading experiment. The result may also imply that the consequences of laboratory experiments for subjects who had not participated in any such type of experiment were not equal to those for subjects who had participated in the experiment.

Table 7. Estimation results of transaction volumes and average price

4. Concluding remarks

Public announcements of violators' names are frequently implemented in most markets (e.g., a financial market and emission trading scheme) to ensure high compliance rates. Theoretically, public

announcements may increase market participants' shame and in turn suppress their violations. On the contrary, it is also theoretically expected that innocent participants are likely to break a market rule because they are given information about the presence of violators via the announcement. Despite such contradicting expectations, no study has examined their effects on compliance, to our knowledge. To bridge the gap between actual incidents and the academic literature, this study examines public announcements as punishment systems by conducting laboratory market experiments.

Our experiments were conducted 12 times between 2012 and 2014. The settings of punishment systems were different for every experiment (see Table 1). In all experiments, one uniform market rule was imposed. Punishments were given for any violation detected. We drew up three punishments: fines, public announcements of violators' names and public announcements' of violators' IDs. The expected cost of violation (i.e., fine times detection probability) was set to be less than the theoretical market prices; i.e., subjects could earn more rewards when they broke the market rule. Names were a "direct" type of identifying information; IDs, "indirect". In each experiment, the list of all IDs and seat locations was projected on the screen in the front of the computer room. Therefore, IDs also identified the participants. If subjects did not mind the public announcement of their name, their rewards increased when they broke the rule.

Four remarkable findings were obtained from the laboratory experiments. First, even when the amount of fine was small, fines were the most useful punishment for raising market compliance. This finding may reflect a framing effect involved with paying a fine. Second, public announcements of the names and IDs of violators were helpful in suppressing violations. Market compliance can be ensured by not only monetary interventions, such as fines, but also by information disclosure, such as via public announcements. Third, the deterrence effects of announcements of violators' names were larger than those of the announcements of their IDs. Therefore, it is important for authorities to understand the content that is publicly announced. Fourth, when publicly announcing violators' names, market transaction volumes and prices decreased and increased, respectively. This finding implies that the announcement of name may have an influence on market welfare.

We close this study by mentioning several limitations to guide future works. First, this study focuses on entire market compliance/violation behaviors instead of individual market compliance/violation behaviors. Therefore, future works need to analyze individual decision making on compliance with individual data. Second, the market welfare is not discussed in this study. Because punishment systems, particularly announcements of violators' names, are found to be relevant to the market price and transaction volumes, it is necessary to examine the changes in market welfare caused by the punishments. Third, it is found that outcomes from the market experiment greatly depend on subjects' past experience with the experiment, that is, learning effects. More arguments about the effects are needed to examine precisely the relationship between punishment systems and compliance behaviors.

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Appendix. Experimental instructions (The case of treatment 5)

Experimental instruction

1. Introduction

This is an experiment on the economics of decision making. The instructions are simple, and if you follow them carefully and make good decisions, you will earn money that will be paid to you privately in cash. All earnings on your computer screens are in "experimental yen." These experimental yen will be converted to "real yen" at the end of the experiment. We will conduct a number of periods, and your experimental earning in each period is determined as follows:

Your earnings = Fixed revenue – Total production costs
+ Sale proceeds from seeing coupons – Amount spent when buying coupons
– Fine

Only the fixed revenue is the same amount in each period.

2. Production cost

You must pay production costs when you produce units. The cost of each unit produced is typically different from the cost of other units produced, and your costs may or may not be different from the costs of other participants. Your production costs are shown on the left side of your computer screen. (The numbers for this example are different from the actual numbers used in the experiment, and you will not actually learn your values until the experiment begins.) Everyone can produce up to 10 units, and the cost of each unit is written separately. For instance, your first unit produced would cost 80, and your second unit would cost 100. (These cost settings are based on the sample seen in figure 1.) Your third unit would cost 120. If, for example, you produced three units, your total costs would be

80 (Production cost of first unit) + 100 (Production cost of second unit)
+ 120 (Production cost of third unit) = 300 (Total cost)

Here, you must recognize that the costs are the additional costs associated with each additional unit produced.

3. Coupons

In this experiment, you need to make 10 units in each period. You need to follow this rule. However, you can save your production amount by holding coupons. In short, the actual amount of production is determined as follows:

Actual amount of production = 10 units - The number of coupons you have

This rule means that you can avoid production (and save on your production costs) by holding coupons. Everyone starts with some number of coupons in every period, and anyone can adjust their own holding coupons by buying and selling them in a market that will operate over the computer network. If you sell the coupons, your cash increases by the sale amount, and if you buy coupons, your cash decreases by the sale amount. When you have a successful transaction, you can increase your profit.

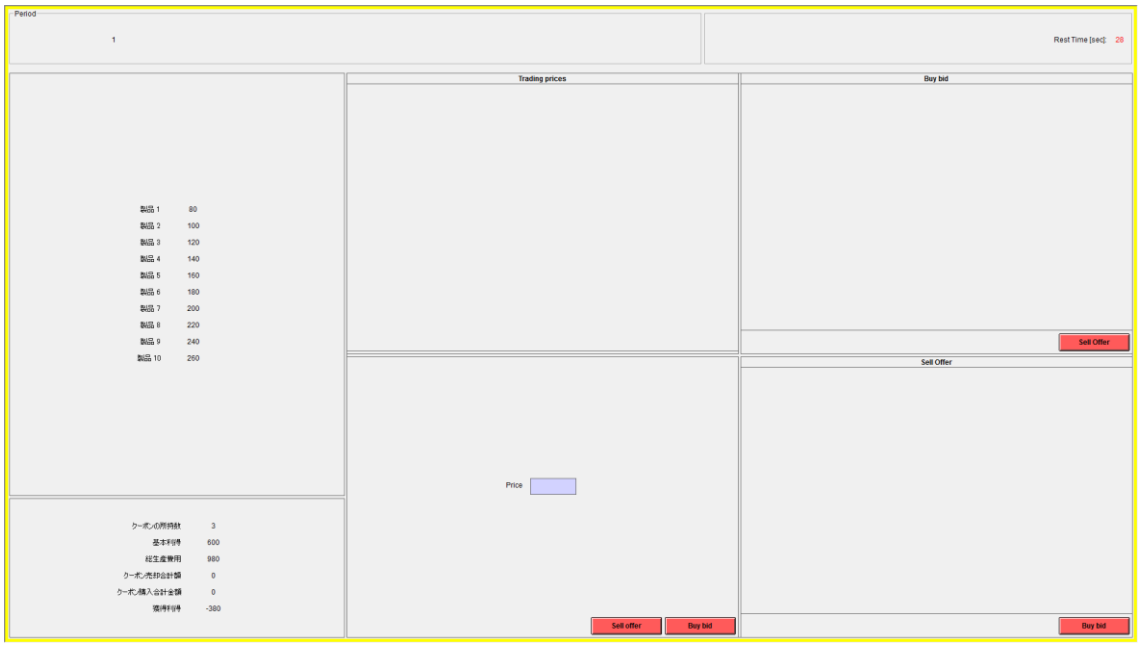


Figure 1. Computer screen in stage 1

Why might you want to buy a coupon? Remember that coupons allow you to avoid production. If you currently hold two coupons, for example, and if you have the example of production costs shown in figure 1, then the production costs of ninth and 10th units are saved, and the last unit that you must produce is the eighth unit (so that your production of 8 units + 2 coupons = 10). The production cost of the eighth unit is 220. Thus, if you can buy a coupon for less than that, it might be

a good idea because it would allow you to save the production cost of 220. More specifically, if you buy a coupon for 150, you save the production cost of 220 and thus make a profit of 70 (= 220 – 150) because of the lower costs that you incur. In this case, you will produce seven units and hold three coupons.

However, you also have a chance to increase your profit by selling coupons. Continuing the illustration based on the previous example, suppose that you currently hold six coupons with the corresponding production costs shown in figure 1. The production costs from the fourth to tenth units are saved, and the last unit that you must produce is the fourth unit (so that your production of 4 units + 6 coupons = 10). The production cost of the fifth unit is 160. If you can sell a coupon of the fifth unit at a higher price than 160, it might be a good idea because this sales revenue exceeds the production cost for the fifth unit. For example, if you sell a coupon for the fifth unit at a price of 180, even if you incur the additional fifth unit production cost of 160, you will still make a profit of 20 (= 180 – 160) on the sale. In that case, you would produce five units and hold five coupons.

4. Stages 2 and 3: Decision making of production amount and report of your production

In stage 2, you decide the production amount based on your coupon trading result. Although the inspector figures out how many coupons each subject holds, he cannot always understand how much each subject produces. Therefore, the inspector may inspect and determine your actual production. The probability of inspection is 50% per period. If he determines that your actual production differs from your reported production, then you will pay a fine based on the difference between these production units. The amount of the fine (per unit) is 230. In addition, your name and the shortage of the production amount are announced to all subjects in the room.

Figure 2. Computer display in stage 2

Figure 3. Computer display in stage 3

5. How to buy and sell a coupon

5.1 How to buy a coupon

There are two ways to buy a coupon in stage 1.

1. Submit a “buy bid”—Participants interested in buying a coupon can submit a “buy bid” using the “price” box on the lower side of the screen and then clicking on the “buy bid” button on the lower right. This bid price is immediately displayed on all traders’ computers on the upper-right part of the screen, labeled “buy bid.” Once this bid price has been submitted, it is binding in the sense that anyone wishing to sell accepts this price, and this acceptance results in an immediate trade at that price. Then, the trade for that unit of coupons finishes at that moment. If nobody accepts the “buy bid,” then everyone can submit a new buy bid, which must be higher than the current highest bid. Because sellers always prefer higher prices, if you try to bid a lower price than the best bid currently available, your computer will give you an error message.

2. Accept a “sell offer”—The other way to buy a coupon is to accept the best sell offer (that is, the lowest “sell offer” price) by simply clicking the “buy bid” button on the bottom-right part of their computer screen. This results in an immediate trade at that price, and the trade for that unit of coupons finishes at that moment.

5.2 How to sell a coupon

There are two ways to sell a coupon in stage 1.

1. Submit a “sell offer”—Participants interested in selling a coupon can submit a “sell offer” using the “price” box on the lower side of the screen and then clicking on the “sell offer” button below that box. This sell offer is immediately displayed on all traders’ computers on the right part of the screen, labeled “sell offer.” Once this offer price has been submitted, it is binding in the sense that anyone wishing to buy can accept this price offer. This acceptance results in an immediate trade at that price, and the trade for that unit of coupons finishes at that moment. If nobody accepts that sell offer, then a new sell offer can be submitted by anyone wishing to sell, which must be lower than the current lowest sell offer. Because buyers always prefer lower prices, if you try to offer a higher price than the best offer price currently available, your computer will give you an error message.

2. Accept a “buy bid”—The other way to sell a coupon is to accept the best “buy bid” (that is, the highest buy bid) by simply clicking the “offer sell” button on the middle-right side of the computer screen. This results in an immediate trade at that price, and the trade for that unit of coupons finishes at that moment.

When a trade for a particular unit of coupons is agreed upon following the above rule, the trade of that unit is closed. Then, a new trade opportunity for another unit of coupons starts from the beginning. The same trading procedure repeats until the trading duration of 2 minutes is over. You can be both a seller and buyer throughout the trading duration.

Tables and Figures

Table 1. Implemented punishment systems by treatment

Treatment	Fine	Announce1	Announce2	Experimental Date	
0	No	No	No	15-Mar-13	18-Mar-14
1	No	Yes	No	18-Dec-12	9-Aug-13
2	No	No	Yes	17-Mar-14	22-Jun-14
3	Yes	No	No	8-Aug-13	8-Aug-13
4	Yes	Yes	No	9-Aug-13	21-Jun-14
5	Yes	No	Yes	17-Mar-14	22-Jun-14

Note: the experiment at March 15, 2013 was conducted in Tohoku University.

Table 2. Setting of marginal points for coupons

Marginal points for coupons	Type 1	Type 2
1	110	85
2	120	90
3	130	95
4	140	100
5	150	105
6	160	110
7	170	115
8	180	120
9	190	125
10	200	130

Table 3. Results of Mann-Whiteny test for the average number of violations per subject

		A				
		Treat1	Treat2	Treat3	Treat4	Treat5
	Treat0	0.997	8.430 ***	8.601 ***	7.265 ***	11.226 ***
	Treat1	-	6.891 ***	6.991 ***	5.773 ***	9.649 ***
B	Treat2	-	-	0.544	-0.875	3.393 ***
	Treat3	-	-	-	-0.889	3.398 ***
	Treat4	-	-	-	-	4.136 ***

Note: *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Results of Mann-Whiteny test for the average violator rates

		A				
		Treat1	Treat2	Treat3	Treat4	Treat5
B	Treat0	2.219 **	8.266 ***	8.183 ***	7.771 ***	11.335 ***
	Treat1	-	6.144 ***	6.058 ***	5.635 ***	9.334 ***
	Treat2	-	-	-0.089	-0.530	3.475 ***
	Treat3	-	-	-	-0.440	3.562 ***
	Treat4	-	-	-	-	3.990 ***

Note: *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Estimation results for the average number of violations per subject

	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Fine	-1.52	0.21 ***	-1.48	0.21 ***	-1.39	0.21 ***
Announce_1	-0.51	0.16 ***	-0.50	0.16 ***	-0.41	0.16 ***
Announce_2	-0.58	0.22 ***	-0.82	0.20 ***	-0.89	0.21 ***
Fine×Announce_1	1.16	0.32 ***	1.10	0.32 ***	0.81	0.30 ***
Fine×Announce_2	1.05	0.58 *	1.32	0.54 **	1.00	0.57 *
Round	-0.04	0.02 *	-0.01	0.02	-0.01	0.02
Price (Mean)	-0.05	0.01 ***				
Price (Median)			-0.04	0.01 ***		
Price (Last 3 trades)					-0.02	0.01 ***
Second time	-1.64	1.35	-1.66	1.30	-1.18	1.35
Third time	1.61	3.76	1.11	3.68	-1.51	3.63
Constant	6.85	1.41 ***	5.67	1.23 ***	2.88	0.71 ***
Log likelihood	93.21		92.08		90.73	

Note: Robust standard errors are used. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Estimation results for the average violator rate

	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Fine	-1.35	0.08 ***	-1.34	0.08 ***	-1.27	0.08 ***
Announce_1	-0.12	0.05 **	-0.12	0.05 **	-0.02	0.05
Announce_2	-0.71	0.09 ***	-0.85	0.08 ***	-1.00	0.08 ***
Fine×Announce_1	0.84	0.12 ***	0.84	0.12 ***	0.55	0.11 ***
Fine×Announce_2	0.71	0.18 ***	1.01	0.18 ***	0.60	0.18 ***
Round	0.00	0.01	0.02	0.01 ***	0.03	0.01 ***
Price (Mean)	-0.04	0.00 ***				
Price (Median)			-0.04	0.00 ***		
Price (Last 3 trades)					-0.02	0.00 ***
Second time	-0.18	0.41	-0.40	0.41	0.46	0.40
Third time	3.62	1.19 ***	3.60	1.18 ***	0.44	1.14
Constant	9.18	0.46 ***	9.03	0.42 ***	5.61	0.22 ***
Pseudo R^2	0.52		0.54		0.50	
Wald	1133.81	***	1162.71	***	1082.19	***

Note: Robust standard errors are used. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Estimation results of transaction volumes and average price

	Transaction volumes				Price (mean)			
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Fine	-2.84	2.60	3.65	3.65	-0.17	1.41	-3.61	1.67 *
Announce_1	-5.86	2.82 *	2.00	3.78	-0.70	1.56	-4.29	2.13 *
Announce_2	-10.15	2.96 ***	-9.95	3.15 ***	9.11	1.61 ***	8.33	1.86 ***
Fine×Announce_1			-17.67	4.99 ***			8.33	2.78 ***
Fine×Announce_2			-4.75	5.71			4.48	3.25
Round	2.52	0.34 ***	2.52	0.34 ***	-0.54	0.21 ***	-0.54	0.20 ***
Second time	17.22	9.66 *	20.92	11.61 *	-11.28	4.73 **	-16.17	6.26 **
Third time	81.25	27.00 ***	107.10	28.59 ***	121.44	13.26 ***	115.51	16.50 ***
Constant	43.09	2.54 ***	39.85	2.79 ***	130.84	1.61 ***	132.56	1.65 ***
F-value	13.10	***	4.76	***	30.78	***	23.64	***
R-squared	0.34		0.40		0.60		0.62	

Note: Robust standard errors are used. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Figure 1. Transition of the average number of violations per subject by round and treatment

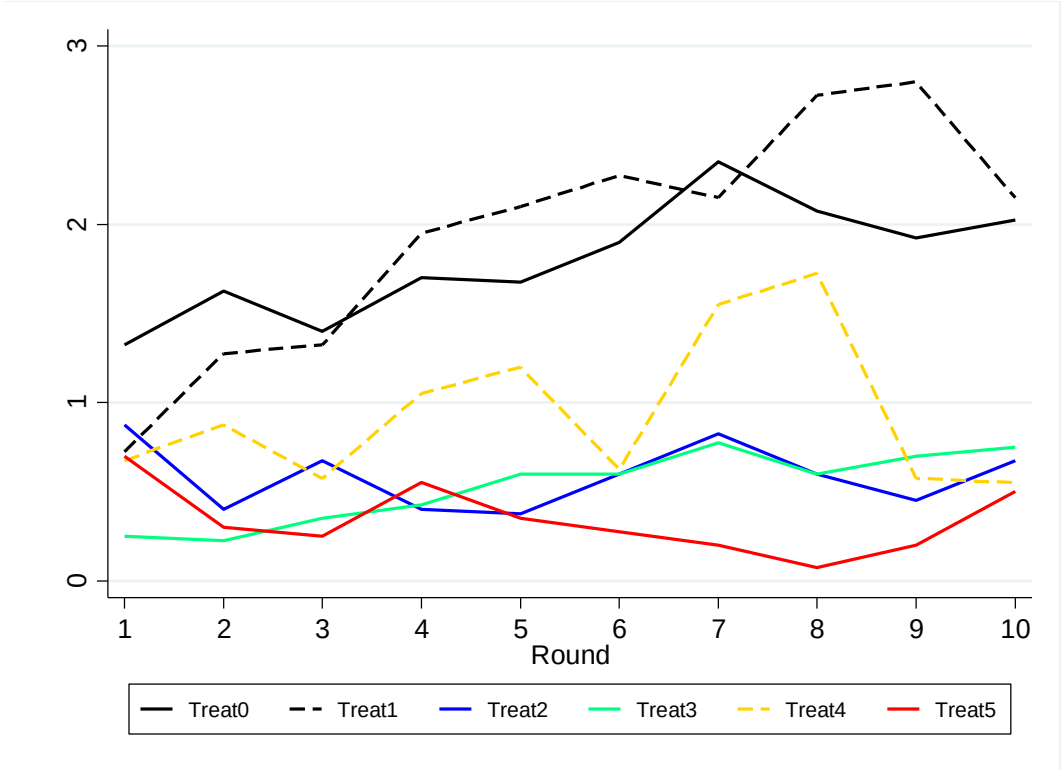


Figure 2. Transition of the average violator rate by round and treatment

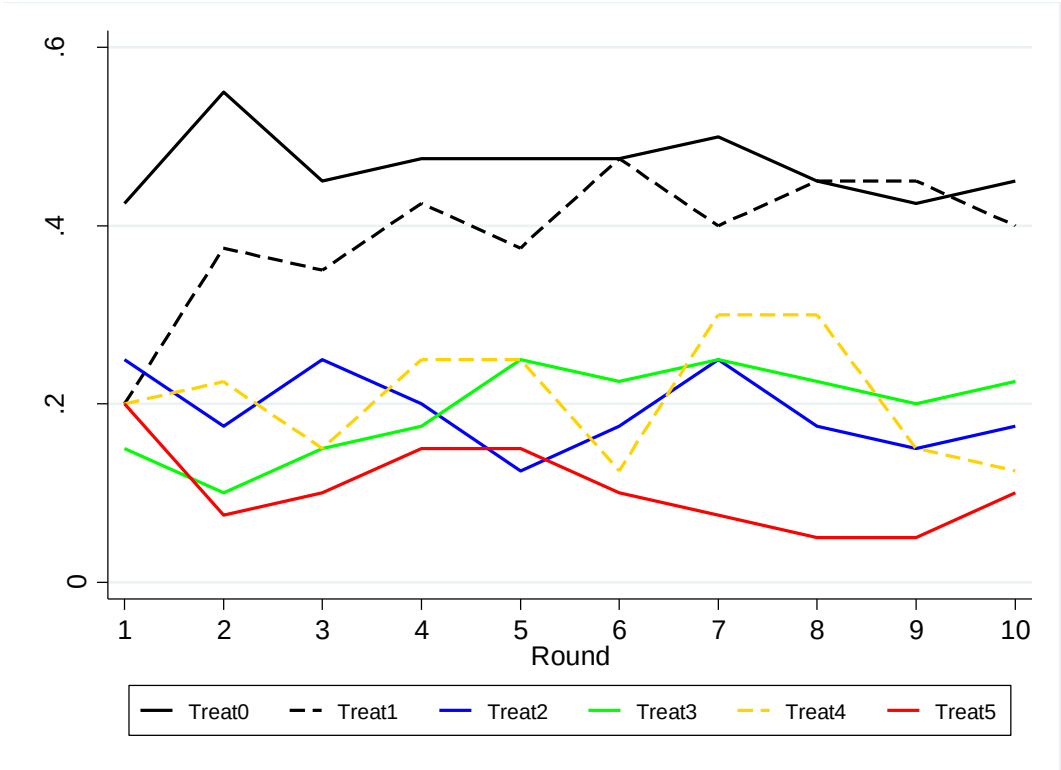


Figure 3. Transition of the average market price by round and treatment

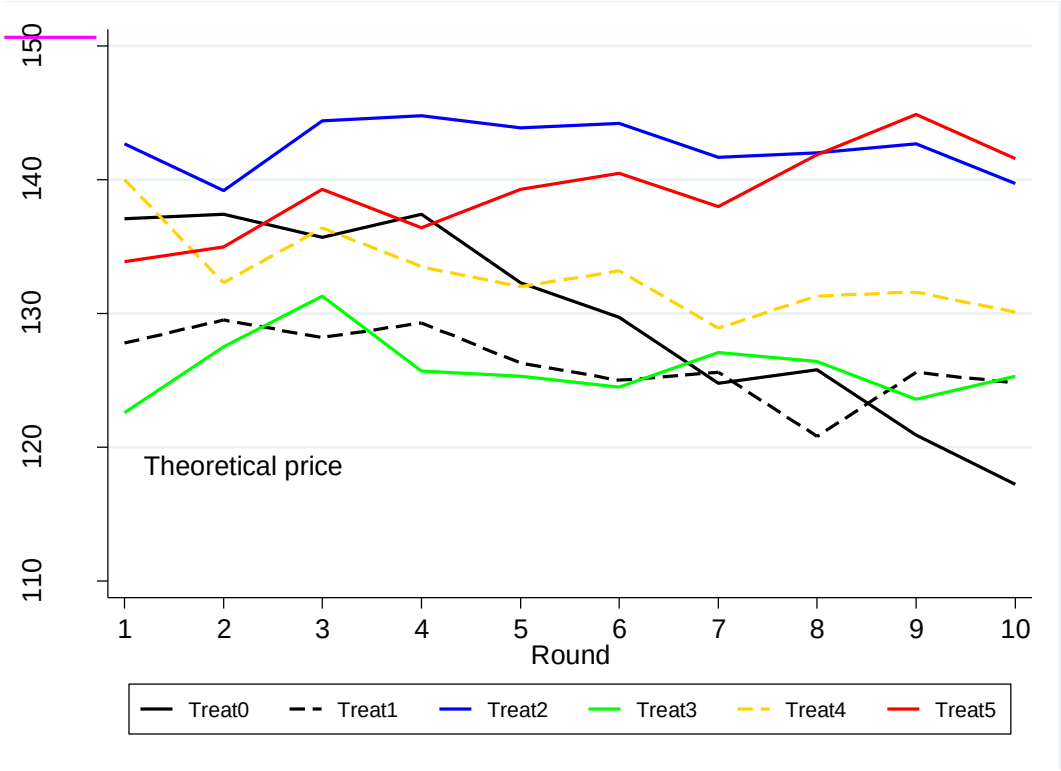
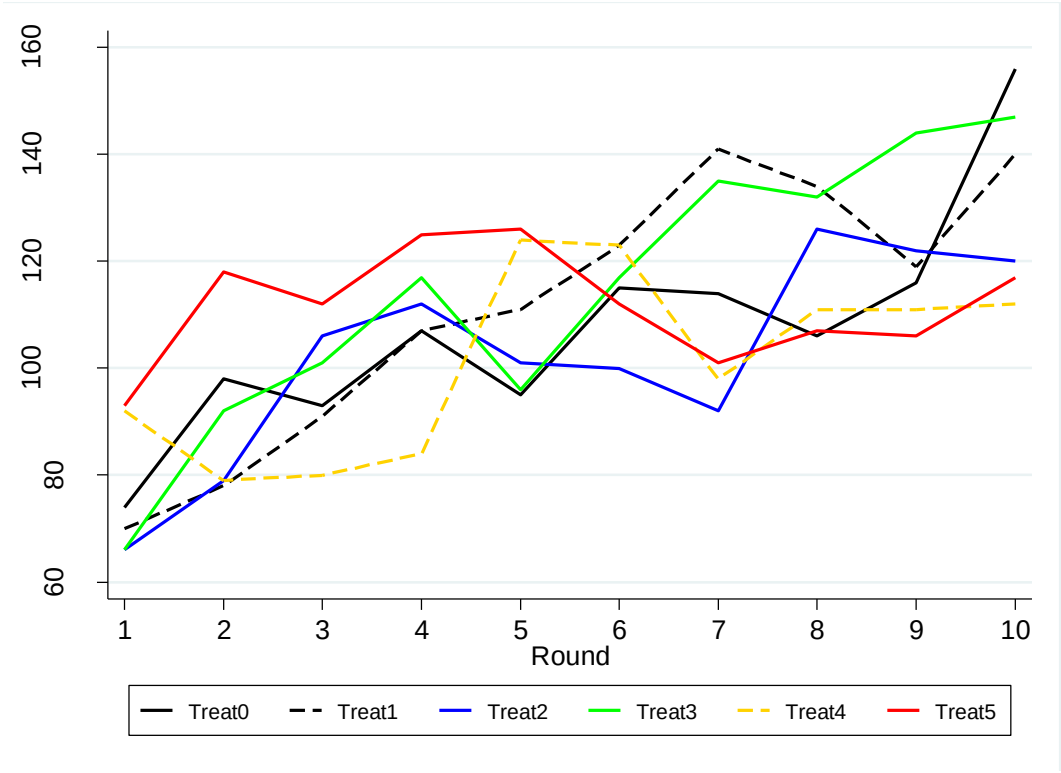


Figure 4. Transition of transaction volumes by round and treatment



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