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Corruption and Pollution in Two Systems: An Experimental Study

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by

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Abstract

Previous studies have found that corruption undermines governmental protection of environment. Since corruption is a common symptom of political structure weakness, our study uses an experimental approach to investigate the institutional effect on corruption. Two types of political systems are designed in the experiment: rule of law and case-by-case exemption. Mixtures of these two systems exist in most countries; thus framing the two systems separately in the simulative environment allows for the understanding of the possible change of corruption level when the actual mixed system moves from one end of the spectrum toward another. The result suggests that the corruption level is lower and environmental standard is higher in the rule of law system than the case-by-case exemption. However, the institutional effect on economic welfare remains uncertain.

Keywords: Corruption, political contribution, voluntary payment, public good, institutional effect, rule of law, case by case exemption, and environmental standard

JEL Classification: H41, K42

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1 Introduction

Corruption may be as old as the creation of institutions and the practice of rule making and enforcement. However, its significance varies over time and from one society to another. Scholars have found that the institutional structures and political processes are important determinants of the level of corruption(Shleifer and Vishny(1993)(23), Blake and Martin(2006)(2), Gerring and Thacker(2004)(8)). They also found that the effects of corruption, given their their illicit nature, are understandably difficult to measure. When corruption data do not exist, or the existing data do not fully reflect what happens in reality, it obviously is difficult to analyze the effects of institutions on corruption. The objective of this study is to use experimental methods to obtain evidence regarding whether corruption is encouraged or inhibited under different institutional environments. Because the evidence is collected in a laboratory environment, data quality can be controlled, by that avoiding the data challenges often faced in the "real world". In the experiment, two types of ruling systems are created: rule of law and case-by-case exemption. Quantitative measures of corruption obtained from the experiment can be used to contrast the effects the two systems have on the corruption level. The differences in social welfare and environmental standards under the two systems can also be analyzed.

The consequences of serious corruption for a country can include political instability, social disruption, and economic sluggishness. Empirical evidence shows that corruption, acting through various channels, tends to retard economic progress. Mauro(1995)(17) finds that corruption lowers investment and thereby lowers economic growth. Mo(2001)(18) shows a 1% increase in the corruption level reduces the growth rate in GDP by about 0.72%. He also finds that the most important channel through which corruption affects economic growth is political instability and it accounts for about 53% of the total effect.

Recent research illuminates the connection between corruption and environmental degradation. Studies show that corruption can indirectly affect the environmental quality through different channels, such as economic growth and instability of political systems. Contributors to the literature on Environmental Kuznets Curves (EKC) propose an inverted U shaped relationship between economic growth and environmental degradation. Grossman and Krueger(1991)(9) using a cross section data on 42 countries, find for two pollutants (sulphur dioxide and smoke) that the degree of concentrations increase with per capita GDP at low levels of national income, but decrease with GDP growth at higher levels of income. Panayotou(1997)(19), Carson, Jeon and McCubbin(1997)(3), Shafik and Bandyopadhyay(1992)(21) and Kaufmann, Davidsdottira, Garnhama and Pauly (1998)(13) arrived at similar conclusions but with different estimates of the level of income per capita where emission starts to decrease. Providing the inverted U shaped relation is supported, corruption can indirectly affect the environment by delaying the economy's progression toward the turning point or make the attainment of the turning point impossible, so the environment is always in a depleted state.

Subsequent research discovered other institutional effects on environmental policy and corruption, which may link political structure, pollution and corruption together. Torras and Boyce(1998)(24) found evidence of the positive effect democracy has on environmental quality when they estimated the Environmental Kuznets Curves (EKC) for sulphur dioxide, smoke, heavy particles, dissolved oxygen, fecal coliform, availability of safe water, and sanitation. Harbaugh, Levinson and Wilson(2002)(10) provided similar results when they included a democracy index in their estimate of the EKC; they found a consistent negative relation between sulphur dioxide and democracy levels. Shen and Williamson(2005)(22) confirm that democracy, as measured by indicators of political rights, civil liberties, and press freedom, has a positive effect on the perceived level of corruption. Pellegrini and Gerlagh(2006)(20) find that the correlation between indices of corruption and democracy is -.68, statistically significant at the 1% level. Their finding favors democracy as a political system which may have a greater chance to produce effective environmental policy due to less pervasive corruption.

While empirical studies establish the indirect effect of corruption on environmental degradation, the direct effect of corruption on sustainable development has long been a fascinating topic for game theorists. Economists constantly use noncooperative games as models of the relationship between regulators and bribers. These models lead to the conclusion that corruption will cause lower stringency and lax enforceability of environmental policy. Lopez and Mitra(2000)(16) present a game theoretic model in which income transfer from a producer lobby to the government has a negative monotonic relationship to environmental policy stringency. Farzin and Zhao(2003)(6) analyzes a firm's optimal lobby behavior and its negative effect on investment in pollution abatement capital.

In view of the negative impact of corruption on economic development and environmental sustainability, social scientists are interested in defining the role of different political institutions in reducing corruption. Lederman, Loayza and Soares(2005)(14) find that democracies, parliamentary systems, political stability, and freedom of press are all associated with lower corruption. Weingast(1997)(25) uses game theory to show that political officials' self imposed respect for boundaries and limits helps to maintain political stability, which has a positive effect on corruption control. He also points out that social pact and the writing of a constitution are two means to construct limits. According to American legal scholar Lon Fuller's book "The Morality of Law"(7) and multinational organizations' definitions (such as World Bank and Freedom House), written legal rules and social contracts among citizens are important elements of the rule of law.

Although recent literature has intensively examined the relationship between corruption and democracy, only very limited discussion focuses on the connection between rule of law and corruption. Although the literature mentions "rule of law" as one of the factors that could suppress corruption(11), it generally leaves out the rule of law in discussing the factors that prevent environmental degradation. Therefore, an interesting question remains if the rule of law also has an influence on environmental policy as democracy does. For rule of law is known by itself not only to function as an institutional instrument but also embeds in the society as a prevailing value that shapes the political and economic structure(4). In this regard, the definition of rule of law in the UN Secretary-General Report(1) helps to explain how rule of law can support the good governance and the stability of democracy.

> " Rule of law refers to a principle of governance in which all persons, institutions and entities, public and private, including the State itself, are accountable to laws that are publicly promulgated, equally enforced and independently adjudicated, and which are consistent with international human rights norms and standards. It requires, as well, measures to ensure adherence to the principles of supremacy of law, equality before the law, accountability to the law, fairness in the application of the law, separation of powers, participation in decision-making, legal certainty, avoidance of arbitrariness and procedural and legal transparency."

The definition is an echo of Weingast's conclusion. Based on the definition, it is clear that a country that is ruled by law will apply procedural fairness and legal norms to all and will protect individuals' fundamental rights. Political institutions function more properly by following principles. The system is not easily manipulated by anyone because the law protects all individuals' human and economic rights. At the same time, a parliamentary system will not be manipulated by a few people if everyone acknowledges the law has supremacy in governing their actions.

As previous researchers have pointed out, democracy and well protected fundamental rights reduce corruption and strengthen environmental policy. It is reasonable to hypothesize that the rule of law principle also plays a significant role in preventing corruption and strengthening pollution control because good democratic practices and well protected human rights are both supported by the constitution and the social contract. To examine this, we design an experiment based on the definition of the third type of rule of law which is proposed by Richard H. Fallon, a scholar at the Harvard Law School, to simulate a rule of law system and a case-by-case exemption system. According to Fallon's(1997) definition (5), this type of rule of law emphasizes procedural fairness. In his concept, the law should be partly rooted in an adequate process, and it is important to identify the kinds of institutions appropriate to render particular kinds of decisions to satisfy the procedural demands to legitimate the judgements. Therefore, in the experimental design, the fundamental principle for the rule of law system is to apply rules to everyone without exception, while in the case-by-case exemption system exceptions can be made by officials' discretion. Using such a design, the experiment intends to explore the following hypotheses in connection with the effect of rule of law on corruption and policy efficiency.

Hypothesis 1. Voluntary income transfer from industry to the government is less common in a rule of law system than in a case-by-case exemption system because a free rider problem exists in the former system but not in the latter.

The principle of rule of law is generally based on the fairness of procedure and the supremacy of law. When the environmental standard is codified as a written legal rule, it can only be changed through the policy making process. People with common interests often exercise disproportionate power to influence the policy making process by making political contributions or paying bribes. When a desired policy outcome is considered a public good, free riders may abstain from lobbying activity. Firms that stand to benefit from a lower environmental standard may have a chance to free ride by not making any voluntary payment. The incentive to pay off politicians is reduced in the system that is ruled by law compared with systems that do not have the free rider issue.

Hypothesis 2. The environmental policy stringency will be greater in the rule of law system.

If corruption is less common in the rule of law system, rent-seeking firms will have less influence on the environmental policy under this system. The less corrupted system means a more stringent environmental policy and less environmental degradation.

Hypothesis 3. Higher environmental standards in the rule of law system tend to reduce social welfare when the increase in the utility derived from the improved environmental quality is not included.

Hypothesis 3 is a restatement for the conflict between economic growth and environmental protection. In our experiment, higher standards mean higher production cost. If hypothesis 2 is supported, producers' net profit will be lower in the rule of law system. A smaller producer surplus will lower the social welfare, given an unchanged consumer surplus. Taking politician/regulator's welfare into consideration, the argument in hypothesis 1 also appears to have a negative effect on the welfare of a rule of law system. Overall, the social welfare is lower under the rule of law when the improved environmental quality is not included.

In section 2, we provide details of an experiment designed to evaluate the hypotheses. The results of the experiment are presented and discussed in section 3. The conclusion is in section 4.

2 Experimental design and procedures

2.1 Experiment design

We frame the experiments as production decisions under two systems: a rule of law system and a case-by-case-exemption system. In both systems, each firm needs to decide its output level and the amount of its voluntary payment to the regulator. The amount of voluntary payment determines the policy standard applying to the firms. Higher policy standards mean higher production cost.

In the experiment, each subject represents one firm. The economy comprises 6 firms, which produce identical products. The only important factor input of concern here is fuel. Two types of fuels can be used in the production process: traditional fuel and green fuel. Traditional fuel is cheap but causes a lot of pollution. Green fuel is clean but very expensive. Mixing the two fuels in the production process is possible. When a greater percentage of traditional fuel is used, the firms have lower unit production costs but higher pollution emissions.

In the rule of law system, the amount of political contributions is used as a proxy for the corruption level. Political contributions are legal in most democratic societies. However, they are still considered as indicative of a type of corrupt activity. For example, World Bank World Governance Indicator uses the extra payments made by firms to influence law, policies and regulation to evaluate the country's ability in corruption control(12).

In most of the democratic countries, political contribution is an important financial source for politicians' campaign activities. Political science scholars often define political contribution as a way for individuals or groups to access politicians. Larger political contributions buy greater access. The experiment requires each firm to decide the amount of its political contribution in each round under the rule of law system. The government then sums up all the contributions and determines the policy standards. Before individual contribution decisions are made, subjects are provided with the information on the relationship between aggregate contribution and policy stringency as in Table 1. Because policy stringency is proportional to production cost, unit production cost directly reflects the environmental standard government adopted.

The baseline unit production cost for the firm is set at the highest level, $260. The production cost can be reduced if the firms are willing to make political contributions to the politicians. The greater aggregate contribution the firms make, the greater cost reduction they will have. In the beginning of each round, the production cost is reset to $260.

Table 1: Total contribution and unit production cost for rule of law

Total contribution	below $2400	$2400-$4800	$4800-$7200
Unit production cost	$260	$180	$140
Total contribution	$7200-$9600	$9600-$12000	above $12000
Unit production cost	$110	$90	$80

Under the rule of law system, the firms are asked to make individual political contributions at the beginning of each round. The design does not allow collaboration among the firms. Though many democratic systems allow firms to form a lobby group, the experiment aims to investigate corruption in a oligopoly market where collusion is difficult. To simulate such an environment, we simply prohibit collaboration among the firms.

After individual contributions are chosen, subjects are informed of the updated unit production cost based on the aggregate contribution. Each firm has no knowledge about other firms' contributions. But when firms receive the updated cost, they are also provided with this round's aggregate contribution.

After the cost is determined for this round, subjects are asked to make decisions on output. The inverse market demand function, profit and net profit function are provided to the subject:

$$P = 1000 - 0.5 \sum q_i \tag{1}$$

Equation 1 is an inverse demand curve for the industry. P is the market price. q_i is output for individual firm i. From the demand function, no single firm can unilaterally determine the market price. The market price is determined by the aggregate output of the six firms.

$$Profit_i = Pq_i - Cq_i \tag{2}$$

Equation 2 is the profit function for firm i, i $= 1, ..., 6$. C is the unit production cost. Under the rule of law system, the production cost is the same for all firm in each round.

$$NetProfit_i = Profit_i - Contribution_i \tag{3}$$

Equation 3 is firm i's net profit function. The goal for the firms is to maximize net profit by choosing a desirable contribution level and output level.

The cost C must be one of the six levels of cost that are listed in Table 1. With the information we have, we can calculate the Cournot Equilibrium for the six cost levels. The price, individual output and profit under Cournot equilibrium are provided in Table 2. The same table is also included in the experiment instruction so subjects can decide if they would like to choose the equilibrium as their output choice.

In Table 2, we use the six firms' reaction functions to solve the equilibrium outputs for the six cost levels. The actual outputs that are derived are values with decimal. Using the nonrounded output values, we then calculated market prices and individual profits. Finally, we rounded off the results to an integer and presented them in Table 2. For readers who use the individual output values as shown in the table to calculate the market price and individual profits, they will derive

Table 2: The Cournot equilibrium output, price and profit

Unit production cost	$260	$180	$140	$110	$90	$80
Individual output	211	234	246	254	260	263
Market price	366	297	263	237	220	211
Individual profit	22351	27445	30188	32331	33800	34547

values that are slightly different from the numbers shown in the table. However, the results from using nonrounded or rounded value do not have any effect on the profit ranking for the six cost levels. The differences among each equilibrium profit remains large and almost the same. The decision made by individuals should not be affected if different Cournot equilibrium information that are calculated from either rounded or nonrounded numbers is provided.

Under the case-by-case exemption system, firms face a different cost and payout table. Each firm can apply for exemption from the highest standard $260 by offering a gratuity to the regulator. In the case-by-case exemption, a firm's production cost does not depend on the aggregate contribution level, but only depends on the size of gratuity the firm offers. The greater gratuity the firm can offer, the greater cost reduction the regulator will provide. The relationship between gratuity and unit production cost is in Table 3.

Table 3: Individual and unit production cost for case-by-case exemption

Gratuity	$0	$600	$1000	$1400	$1800	$2200
Unit production cost	$260	$180	$140	$110	$90	$80

The total contribution in Table 1 and individual gratuity in Table 3 may seem to be irrelevant. However, starting from the second level of payment, we use the individual gratuity times 6 to determine the median value of the total contribution in Table 1. For example, using the third column from Table 3, $600 times 6 equal $3600 which is the median between $2400 and $4800 in the third column in Table 1. This design allows us to examine total payment between the two systems on the comparable scale.

In the case-by-case exemption system, the market demand function and the net profit function are exactly the same as in the rule of law system. Only the profit function is slightly altered. The new profit function is as follows:

$$Profit_i = Pq_i - c_i q_i \tag{4}$$

c_i is the unit cost for firm i. Under the rule of law system, all the firms have the same cost in each round. But in the case-by-case exemption, the regulator will give each individual firm a different cost depending on which gratuity level the firm chooses.

2.2 Experiment procedure

The experiment was designed to be part of class activities. Students who participated in the experiment could earn bonus points. The bonus points were given based on a student's total net profit. A student's bonus points increased with his or her net profits up to a maximum of 12 points.

A total of 72 students participated in the experiment. All the students were randomly assigned into six-person groups. The experiment was held in the regular classroom setting. Each experiment consisted of 10 identical rounds. The students were required to finish 20 rounds of experiments–10 rounds for rule of law and 10 rounds for case-by-case exemption. Because all the participants had a basic knowledge of microeconomics, the experimenter only needed to explain the rules and procedures for the experiment. Right before the experiment began, the experiment design, instruction and record sheets were handed to each subject. To help the subjects understand the rules of the experiment, two test rounds were held before the official experiment.

The experiment began with 10 rounds of rule of law, and then followed by 10 rounds of case-by-case exemption. After the experimenter read the instructions, the subjects were asked to write down their contribution decision on paper slips and hand them to the experimenter. The experimenter used a visual C ++ program to derive the total contribution and unit production cost and reported these to the subjects. Subjects then were asked to make an output decision and submit their decision again. After the experimenter input the data, the subjects were shown the information regarding the market price, aggregate output and individual profit for the six firms at the same time. The individual net profits for the six firms were shown separately.

The procedure in the case-by-case experiment is almost the same to the rule of law experiment. The only difference is that in the case-by-case experiment, once a subject decides his gratuity level, the production cost is also determined according to Table 3. Therefore, subjects were asked to make a decision on gratuity and output at the same time in the case-by-case environment. There is no need for the experimenter to provide them with cost information.

To prevent collaboration, subjects were not allowed to talk to each other during the experiment. The seating order was decided by drawing lots. Subjects were given a calculator, a pen and paper. Subjects were also asked to record their decisions and cost-benefit information on the record sheets. By doing so, subjects kept track of information that could improve their decisions when more rounds were completed.

In the rule of law experiment, an individual contribution cannot determine the individual's cost. Lobbying for a cost reduction is similar to a public good. Firms can free ride by choosing low or no contribution and enjoy the same cost level as other firms do as long as they are in the same group. Our experiment design is based on the theory of pubic goods so that the first hypothesis can be assessed. Also, given different levels of production cost, we can see if the lower cost level is chosen more in case-by-case exemption than in the rule of law. This will help to answer the question if the rule of law system leads to a more stringent environmental policy.

3 Result

3.1 Corruption level

Our data support the first hypothesis that the corruption level is lower in the rule of law system than in a case-by-case exemption. Comparing the average of 12 groups total payment over 10 rounds in two systems(Figure 1), it is clear that the payment is higher in the case-by-case for all rounds except for round one and four.

When we compare the average round payment for the 12 groups in the two systems, the general pattern for payment between case-by-case and rule of law still holds. In Figure 2, only group six's total payment under rule of law system is greater than case-by-case exemption. For the other 11 groups, payment under case-by-case system is consistently larger than rule of law system.

The spread of total payment for the 12 groups supports hypothesis 1. Figure 3 is a box and whisker plot showing the total payment dispersion for the two systems side by side. In Figure 3, the dark horizontal line in the middle of the box is the median payment for the 12 groups. The lower bar represents the 25th percentile and the higher bar represents the 75th percentile. We find that case-by-case total payment has a higher median and a shorter spread. Most of the contribution made in case-by-case exemption are higher than the values in rule of law. The cross-group mean of total contributions under the case-by-case system exceeds that under the rule of law system by $21,063.17$.

We further assess the difference of means of total voluntary payments under the two systems to see if they are statistically significant. Permutation tests are recommended by Lehmann(15) for populations whose distribution has no known parametric form . Since we only have 12 groups in each system and the data come from an experiment, the observations do not come from a spe-

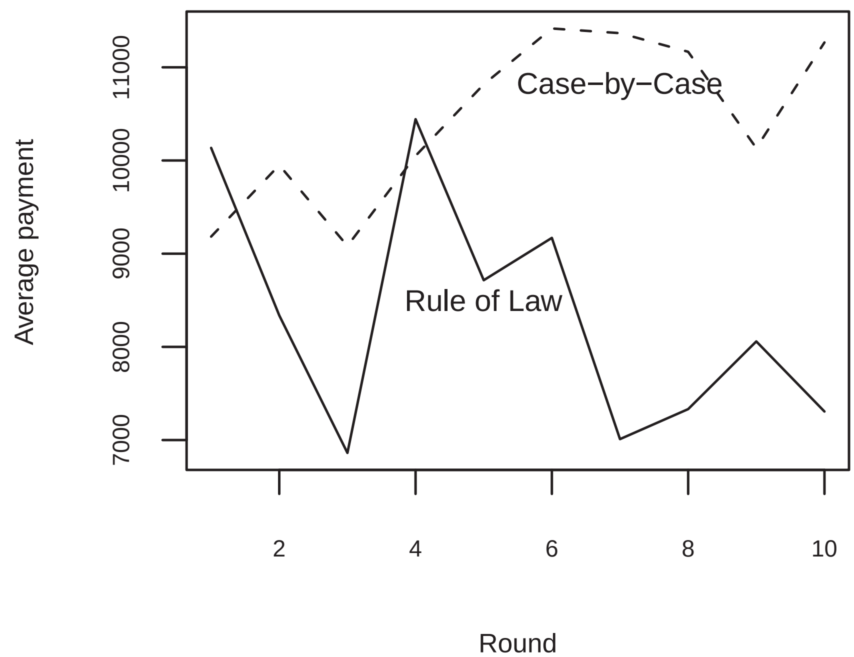

Figure 1: Average total payment of 12 groups

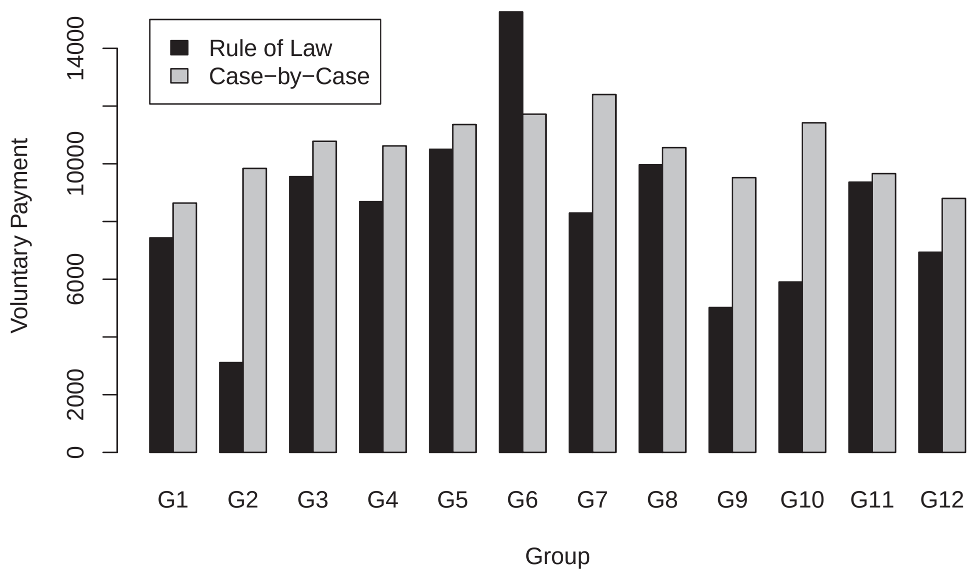

Figure 2: Average total payment of 10 rounds

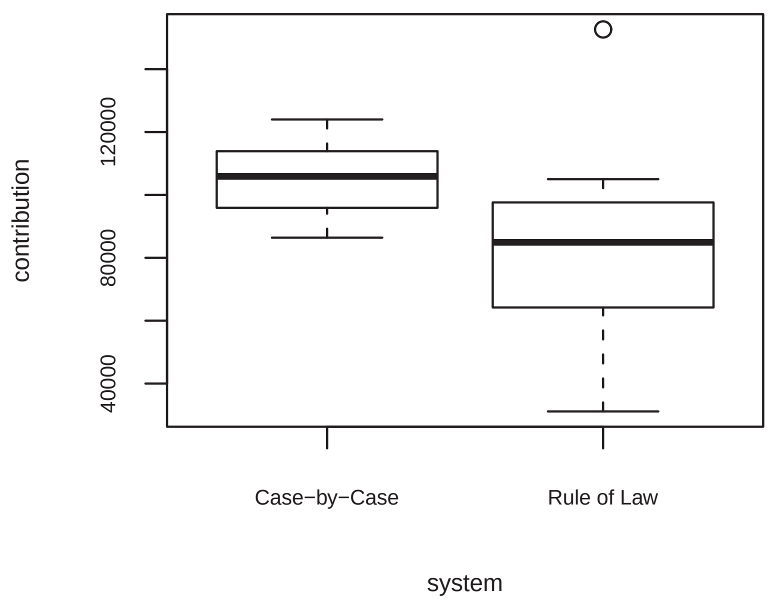

Figure 3: Total payment range for 12 groups

cific parametric distribution. The nonparametric permutation approach is appropriate for our study.

A permutation test starts with pooling observations from two samples and considering alternative partitions of the pooled sample. Suppose sample X has m observations and sample Y has n observation. The pooled sample will contain N observations, where $N = m + n$. In our experiment, each sample has 12 observations and the pooled sample has 24 observation. The total number of partitions of N items into a subset of m items and another of n items is C_n^N, which is 2,704,156 in our case. Only 3.6% of these partitions yield an absolute mean difference greater than or equal to that observed in our experiment ($21,063.17$). Thus the p-value at which we can reject the null hypothesis that the two samples come from the same population is 0.036.

Figure 4 shows the density of the mean difference (based on 100,000 draws) under the null hypothesis that the two samples come from the same population[1]. The peak correspond to the null hypothesis which states that the mean difference is zero. The actual mean difference is directly $-21,063.17$, which is calculated from the sample is . It is far way from from zero as shown in Figure 4.

In general, our data provides strong evidence that corruption is less pervasive in the rule of law environment. When environmental quality is for sale, firms are less willing to pay off politicians in a system that is ruled by law. The major difference between the rule of law system and case-by-case system is the existence of a free rider problem and the uncertainty of the policy outcome. Unsure of the payoff outcome in the rule of law system, firms may hold back contributions. Furthermore, using aggregate contribution to determine production cost gives firms a chance to not pay their "fair share" but still enjoy the same policy outcome. When all the firms act the same way, the overall contribution is low and the production cost is high. Therefore, we believe the incentive to free ride and the uncertainty of the policy outcome are the main reasons that lead to a lower contribution level.

3.2 Environmental standard and pollution intensity

Production cost indicates the environmental standard in the experiment. A higher production cost means a higher standard for the firms and vice versa. There are six levels of cost: 260, 180, 140, 110, 90 and 80. Figure 5 shows the frequency for each cost level that has been adopted over 10 rounds for 12 groups.

In Figure 5, under rule of law(upper panel), the peak frequency[2] occurs near the middle of the

[1]We use R coin one-way-test command to get the exact p-value. But it is computational impractical to have coin package save all 2,704,156 partitions and plot the density of their mean difference. So we use 100,000 random partitions to approximate the density. The p-value for 100,000 draws is 0.037, which is very close to the p-value under the exact test.

[2]The frequency for each cost level means how many times this cost level was realized after the firms pay off the

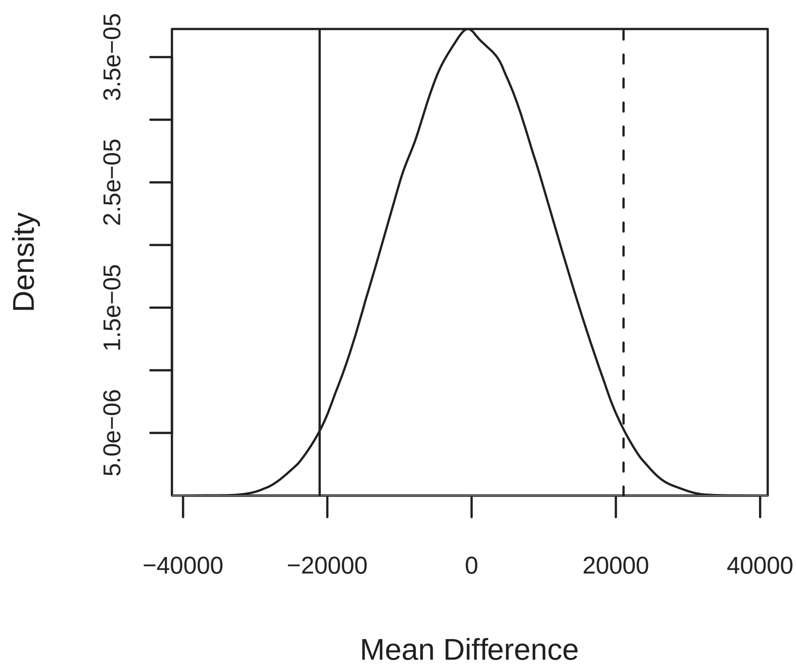

Figure 4: The distribution of the mean difference of total payment under the null hypothesis that the two samples come from the same population(based on $100,000$ random partitions of the combined samples)

range of costs. The highest frequency is at $110, and $140 is the second highest. None of them exceeds 200 times. Under case-by-case exemption(lower panel), frequency attains its maximum at the lowest cost level, where it exceeds 350. It is obvious that middle cost levels were adopted more in the rule of law system while the lowest cost level was more often approved by the government in case-by-case exemption.

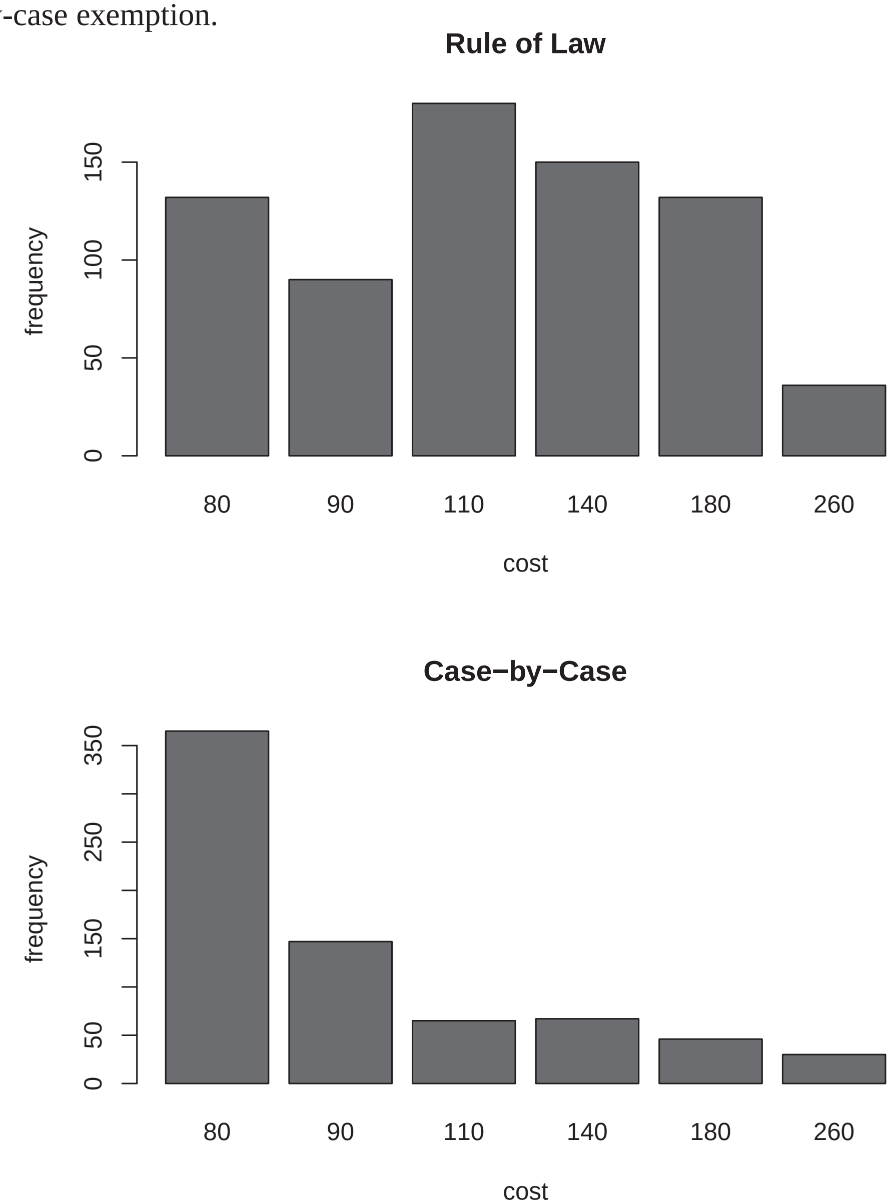

Figure 5: Frequency for each cost levels adopted

The relative frequency of cost levels is indicative of the probability distribution of these levels. Table 4 shows that in rule of law, the relative frequency of the $110 cost level is 0.25 and that

government.

of the $140 cost level is 0.21. The relative frequency does not change dramatically across cost levels. But for case-by-case exemption, the lowest cost level has the highest relative frequency and it exceeds 0.5. This means that the lowest standard is adopted more than half of the time. The relative frequency drops greatly moving from the lowest cost to the second lowest cost. Then we don't see a large difference after the second lowest cost. For example, the relative frequencies for $260, $180, $140, and $110 are all between 4.2% and 9.3%.

The mean cost is $128.45 for rule of law and $104.28 for the case-by-case. To the extent that observed relative frequencies reveal the probability distribution of costs, we can conclude that the expected production cost is much higher under rule of law than under the case-by-case exemption.

Table 4: The frequency and relative frequency of occurance for each cost category

Cost	$80	$90	$110	$140	$180	$260
ROL	132 (18.3%)	90 (12.5%)	180 (25%)	150 (20.8%)	132 (18.3%)	36 (5%)
CBC	365 (50.7%)	147 (20.4%)	65 (9%)	67 (9.3%)	46 (6.4%)	30 (4.2%)

The output cost pattern has an interesting implication for environmental quality. Because the lowest cost is adopted so frequently in the case-by-case system, a great percentage of output in this system is produced at the lowest cost level. When this happens, much of the output is produced by using the least environmental friendly production methods.

The distribution of output across cost levels in the two systems are shown in Table 5. Comparing Tables 4 and 5, we see that under rule of law the distribution of the relative frequency of cost levels is similar to the distribution of output across these levels. In contrast, under CBC the distribution of output is even more skewed toward low cost levels that is the relative frequency of cost levels. 56.5% of output produced at cost $80 and the percentage becomes lower for outputs that are produced at higher costs. It says most firms under the case-by-case system prefer to choose the highest level of gratuity so the lowest cost can be realized more. When cost is low, the firms also decide to produce more in order to gain greater net profit.

In Table 5, the cumulative output percentage shows the pollution intensity for the two systems.

Table 5: Output cost composition

Cost	$80	$90	$110	$140	$180	$260
ROL output	37622	26113	49500	39166	39757	17682
Output percentage	0.18	0.12	0.24	0.19	0.19	0.08
Cumulative output	37622	63735	113235	152401	192158	209840
Cumulative percentage	0.18	0.3	0.54	0.73	0.92	1
CBC output	112812	41302	16371	17600	9253	2484
Output percentage	0.56	0.21	0.08	0.09	0.05	0.01
Cumulative output	112812	154114	170485	188085	197338	199822
Cumulative percentage	0.56	0.77	0.85	0.94	0.99	1

For each cost level from lowest to next-to-highest, the cumulative output percentage under case-by-case exemption is consistently larger than that under the rule of law system. It means the pollution generated from one unit of output production is greater for all levels of cost under case-by-case system. Therefore, we can conclude that the rule of law system places a more stringent standard on firms' production process so the firms choose to have a lower level of emission intensity.

We should be careful in using Table 5 to extend possible implications on environmental quality under the two systems. Since the experiment design did not specify the pollution conversion rates for the outputs that are produced at different cost levels, we cannot say that total pollution levels under case-by-case system is greater than that under rule of law system. However, if the conversion rate is very high for the output produced at the lowest cost, the environmental quality in the case-by-case system will deteriorate at a very rapid pace.

3.3 Welfare analysis

Rule of law discourages firms from paying off the government in exchange for lower costs. It works better than case-by-case in bringing down corruption and money influenced politics. But it also means a more stringent environmental policy may constrain the production activity. A common concern about environmental policy is that raising standards may lower welfare. To assess this concern, it is necessary to compare the aggregate welfare under the two systems to provide some indication of the economic efficiency.

In the welfare analysis, three players' welfare should be taken into consideration: the politician/regulator, the consumers and the producers. Leaving aside for now any welfare effects of environmental change, we focus here on conventional economic gains. Total payment the firms made in each round is the welfare for the politician/regulator. As for the consumer surplus, it can be derived by using the demand function specified in the experiment design. The aggregate net profit in each round represents producer surplus. Figure 6 shows the social welfare dispersion for the 12 groups when we sum up the payment, the consumer surplus, the aggregate net profit over rounds for the 12 groups.

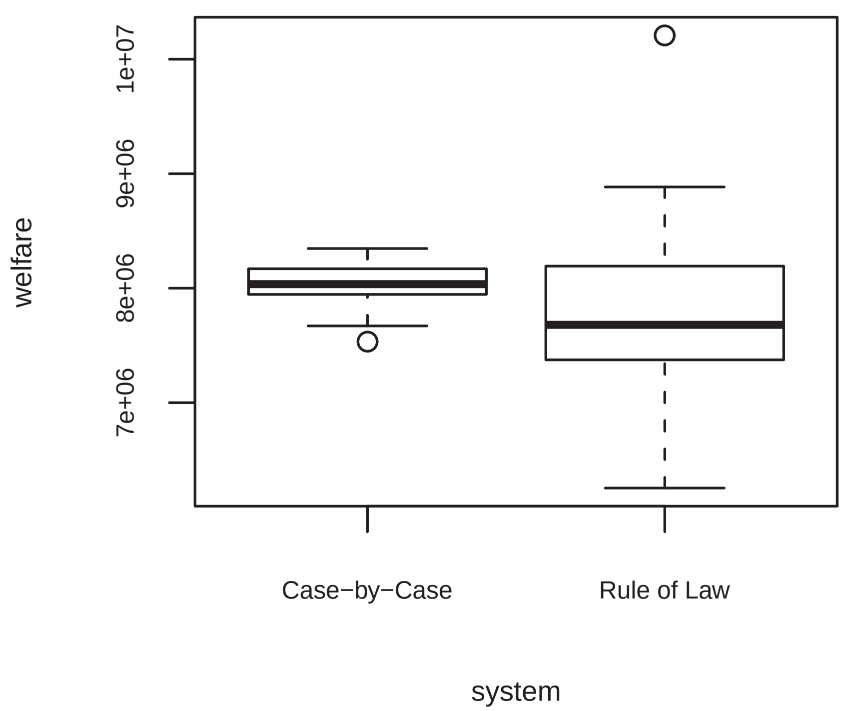

Figure 6: Box plot: Aggregate welfare for the 12 groups

The median aggregate social welfare is much higher under case-by-case exemption than under the rule of law system. The distance between first and third quartile for case-by-case exemption is very short. Most of the values of the 12 groups' social welfare concentrate in a smaller range. Also, the whiskers are very short and the only outlier stays very close to the starting point of whisker. As for the rule of law system, the distance between first and third quartile is much longer than in the case-by-case exemption. The whiskers also stretch a long distance. The only outlier is far away from the whisker.

According to Figure 6, the welfare result is highly variable under the rule of law system. The aggregate social welfare could be very large or small (larger or smaller than the welfare under case-by-case exemption). But if we only compare the median values for the two system, the case by case exemption performs better than the rule of law system.

We apply a permutation test here to see if the means of economic welfare under rule of law and from case-by-case systems could be based on two samples from the same population. The result is in Figure 7. The actual mean difference for aggregate welfare is $-159,951.3$, which is indicated by the solid vertical line. The p-value is 0.61, which is not low enough to reject the hypothesis that the means of the aggregate welfare for the two systems are the same.

Our conclusion is that the welfare under rule of law system seems to be lower than that under the case-by-case system if we only compare the mean. However, permutation test shows that the difference of mean for aggregate welfare under the two system is not significant enough to reject the null hypothesis that the two samples come from the same population. Therefore, we are not certain that case-by-case system will generate a higher level of economic welfare. However, a risk-averse regulator will prefer to use case-by-case exemption because welfare in this system has less variability. Regulators could also prefer case exemption system over the rule of law system simply due to the fact that the aggregate voluntary payment they receive from the case by case system is larger than that of the rule of law system.

The conventional economic welfare analysis should be interpreted with appropriate caution. The aggregate welfare we estimate in the experiment does not include the social benefit associated with higher environmental quality. In order to conduct a complete welfare analysis, it is important to include the utility derived from a better and healthier living environment. Such an analysis would require information of individual preferences on various environmental goods. That information was not collected in our experiment and is not the focus of our study.

In terms of data quality, one may argue that there could be a learning effect in the experimental data. If a learning effect does exist, data from the first two rounds should be discarded. Moreover, there could also be end-round effect, which makes the last round result less reliable. To examine these problems, we plot the variance of individual payments and also the coefficient of variation (standard deviation to mean ratio) of individual payments across rounds. These plots show neither a sudden drop after the first couple of rounds nor a dramatic change in the end round. This means

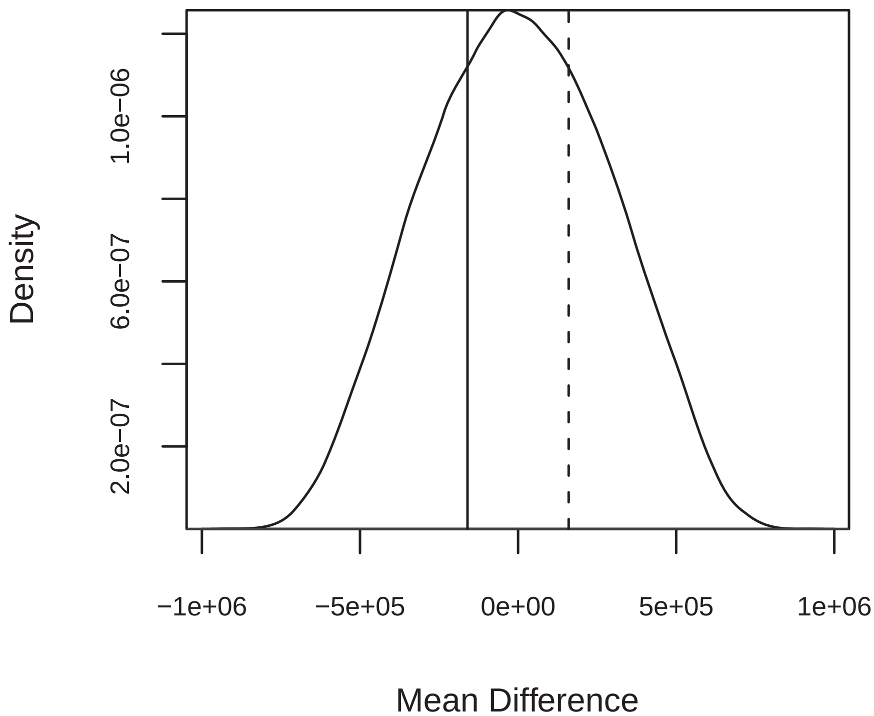

Figure 7: The distribution of the mean difference of aggregate welfare under the null hypothysis that the two samples come from the same population (based on 100,000 random partitions of the combined samples)

that even if the learning effect exists, it is minor. Also, the end-round effect appears to be modest so individuals behave generally the same way in the end round as they did in other rounds. We also plot total contribution's mean difference round by round. Once again, it does not provide any consistent evidence to support the learning effect and end-round effect. Therefore, we decided to use all the data from the experiment. But we also provide figures and tables that include data only from rounds 4 to 8 in the appendix for the readers concerned that the potential learning effect and end-round effect may bias the results.

4 Conclusion

The major contribution of the study is to analyze the determinant of rule of law in reducing corruption from an institutional point of view. We design two systems-one ruled by law, the other ruled by man-and then contrast the voluntary payment from the industry to the government. In particular, we are interested in a Cournot market structure where collusion among firms is forbidden.

We analyze the implications of corruption for the two systems on (a) environmental policy stringency and, (b) the welfare outcomes. The results derived from our analysis are consistent. The institutional differences significantly affect corruption which in turn impacts policy standards and economic efficiency. Three major conclusions emerge from the study:

(a) For a political system based on the rule of law principle, corruption is less pervasive compared with a system that relies on human discretion.

(b) The environmental policy stringency is greater in a rule by law system because industry has less influence on the policy outcome.

(c)Aggregate economic welfare has greater variability under rule of law than under case-by-case exemption when we do not take into account of the value of an improved environment. However, our experiment does not strongly support the hypothesis that rule of law system tends to generate lower economic welfare compared to the case-by-case system.

The implications of these results are very significant for both developed countries and developing countries. For developed countries that make environmental protection their top policy priority, applying a national standard to all without exception tends to lead to a more effective environmental policy. The economy faces a higher standard and lower pollution intensity in production. This does not mean that the economic welfare will be compromised for a more stringent environmental policy since the aggregate welfare is not definitely lower in the rule of law system. However, the incentive for corruption will be discouraged due to the institutional design.

For developing countries that only strive for economic development, applying the same environmental standard to all firms does not seem to be an appealing idea. Using case-by-case review allows producers to capture greater net profit. At the same time, economic welfare seems to be more stable. It is easier for the regulator to project future economic growth. However, it does not mean the economic rent is fairly distributed among individuals. Higher corruption could lead to greater income inequality and the low income population may suffer more from environmental degradation.

The rule by man system provides regulators more opportunities to benefit themselves from the firms' payout. In this process, environmental concerns have to take a backseat. The pollution control is weaker and environmental policy is less efficient in this system. As a result, the pollution intensity tends to be much higher. When the pollution output conversion rate is low, the case-by-case exemption system does not cause too much environmental degradation. But when the conversion is high, the total pollution will be large therefore the country cannot attain sustainable growth in the long run.

5 Appendix

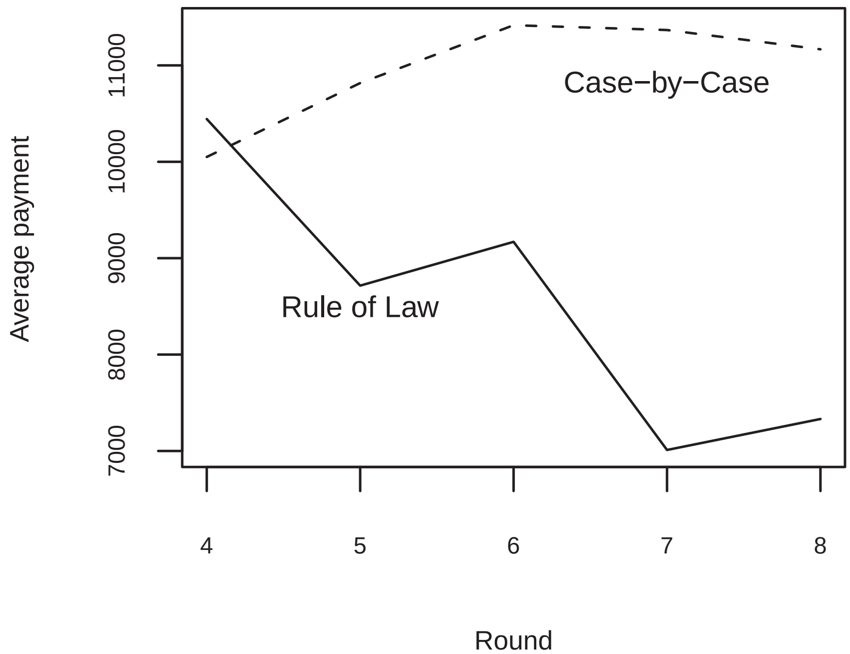

Figure 8: Average total payment of 12 groups for 4 to 8 rounds

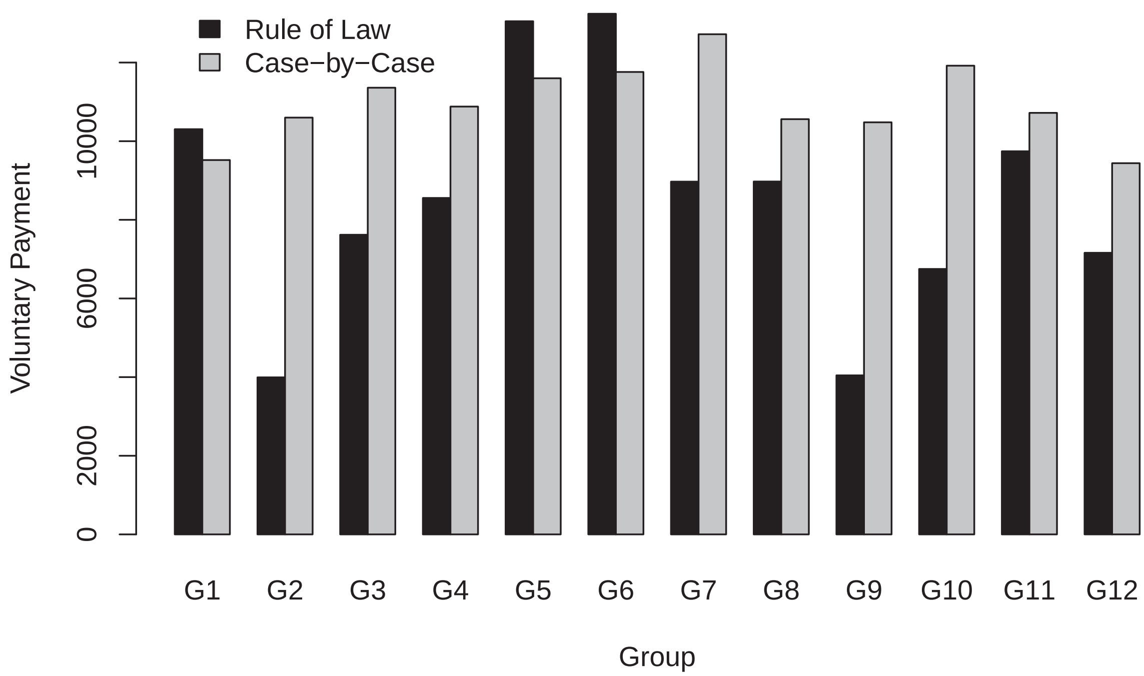

Figure 9: Average total payment of 4 to 8 rounds

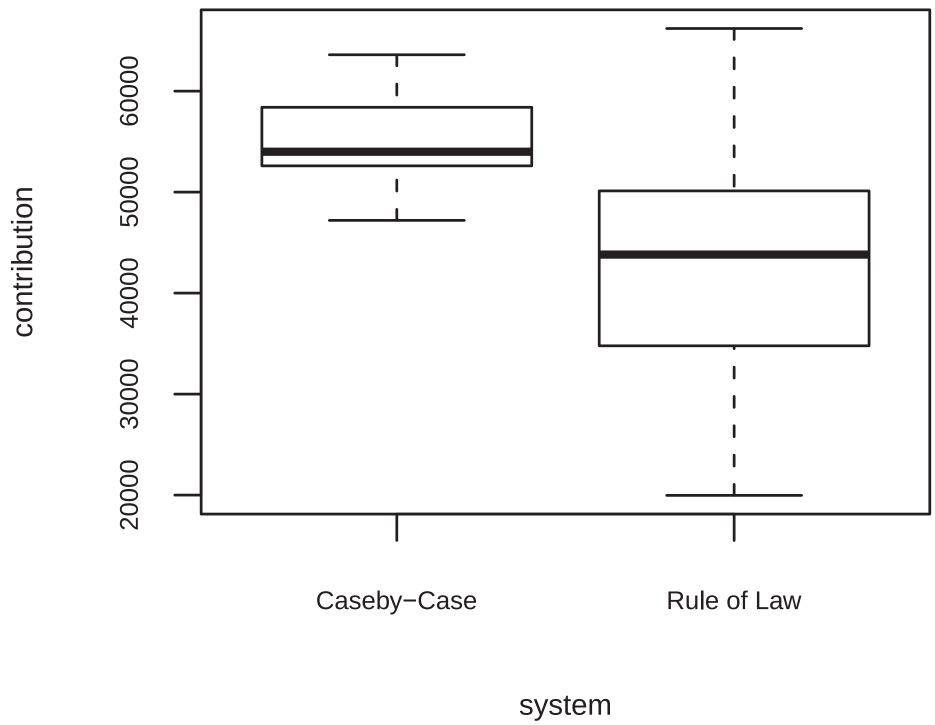

Figure 10: Total payment in rounds 4-8 for 12 groups

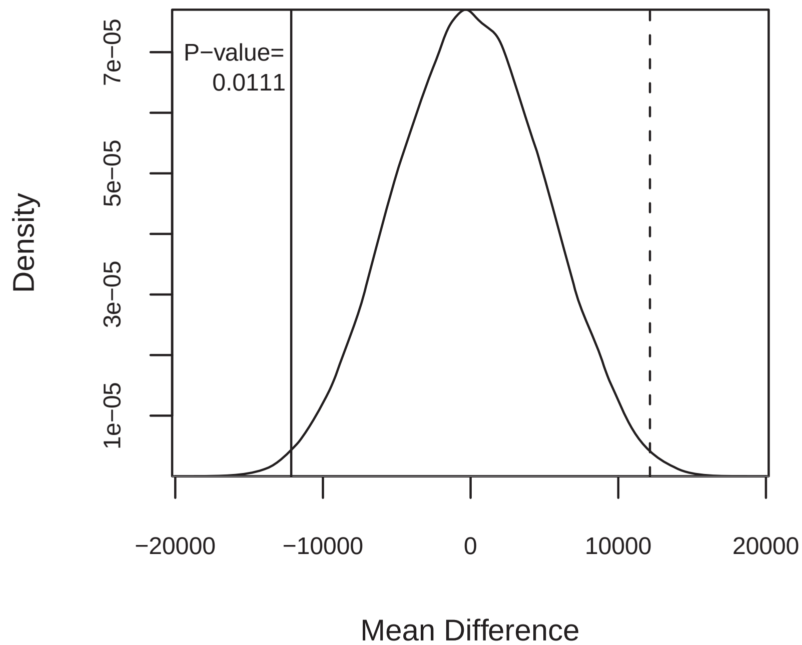

Figure 11: The distribution of the mean difference of total payment under the null hypothesis that the two samples come from the same population:4 to 8 rounds(100,1000 draws)

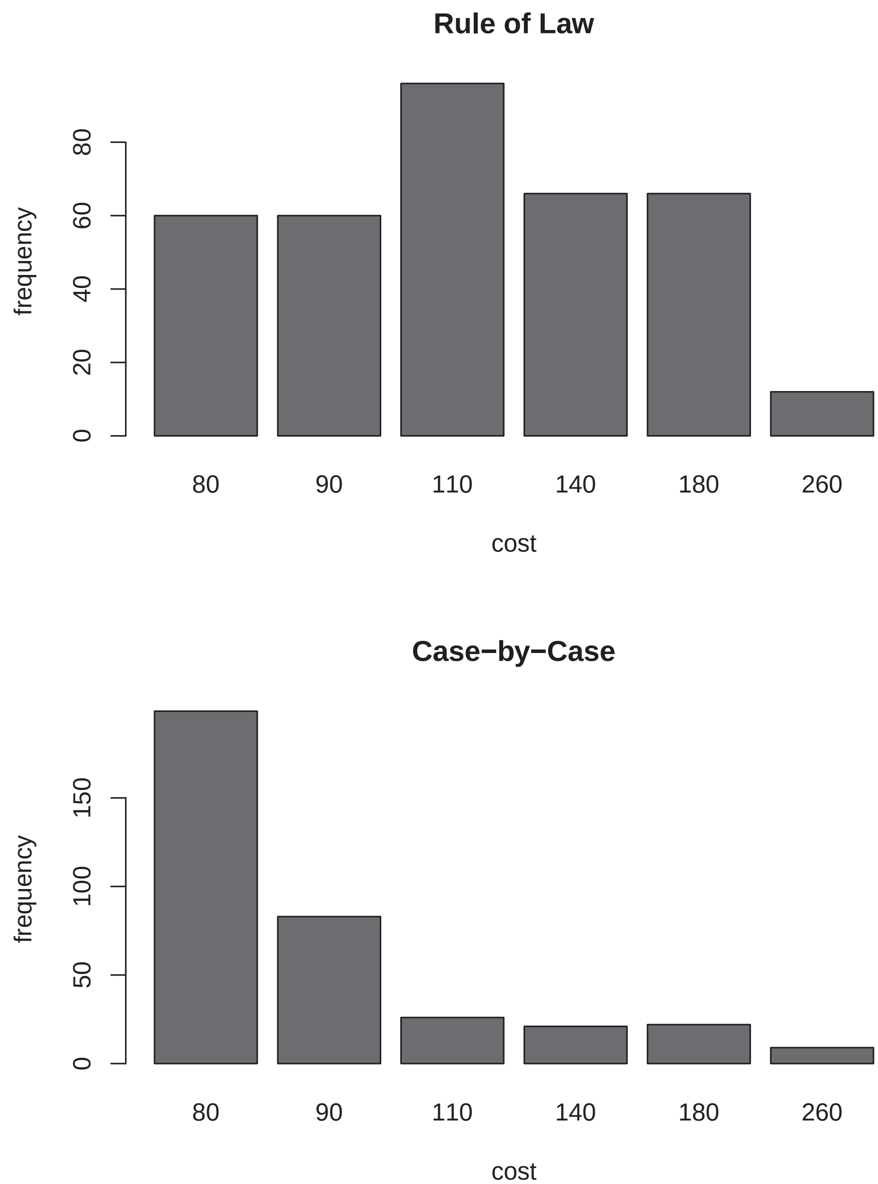

Figure 12: Frequency for each cost levels adopted: 4th to 8th round data

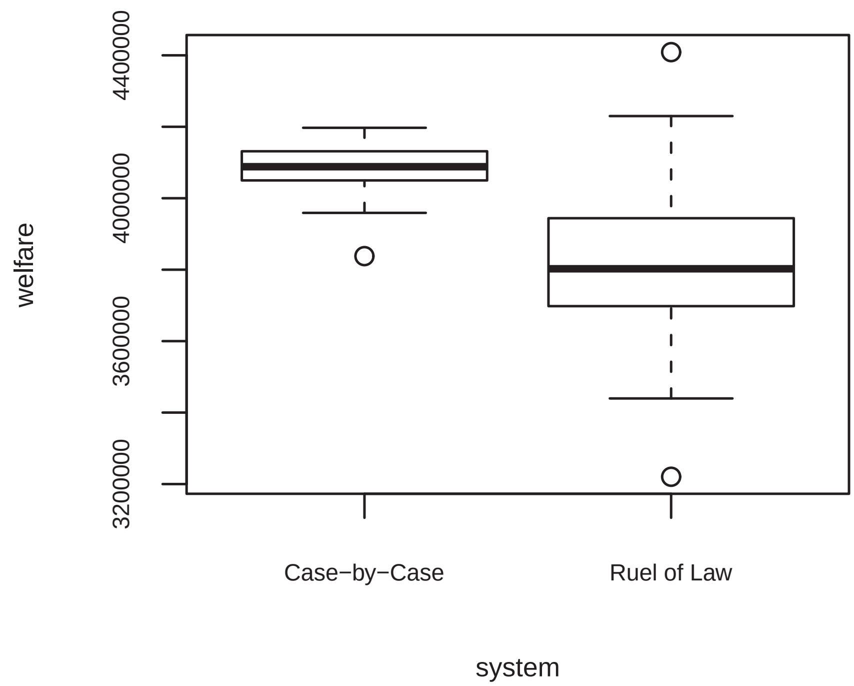

Figure 13: Box plot:Aggregate welfare in rounds 4-8 for the 12 groups

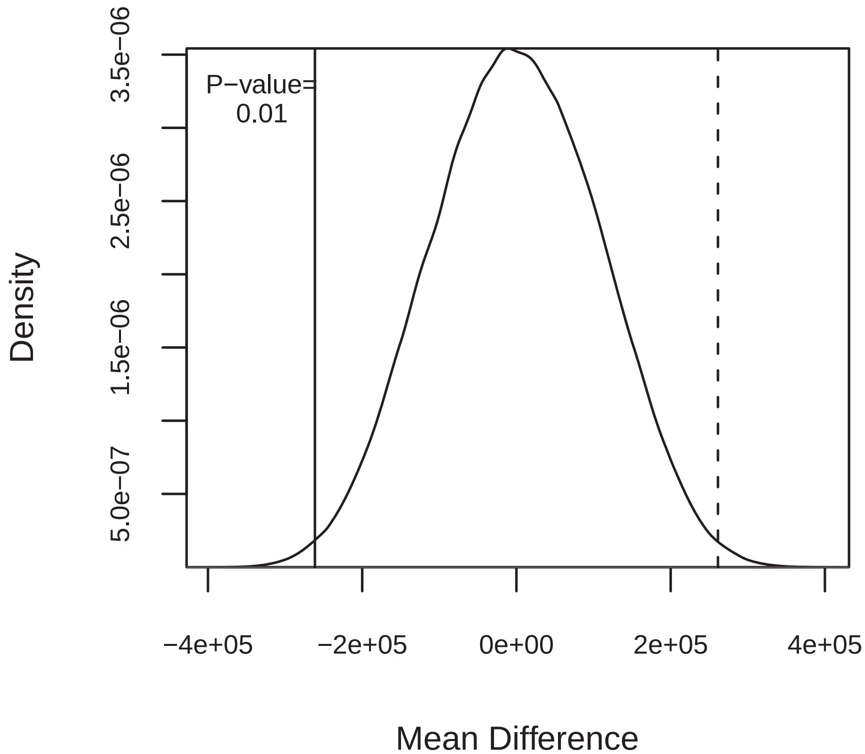

Figure 14: The distribution of the mean difference of aggregate welfare under the null hypothesis that the two samples come from the same population: 4 to 8 rounds (100,000 draws)

Table 6: The probability for each cost category being adopted: 4th to 8th round data

Cost	$80	$90	$110	$140	$180	$260
ROL	60 (16.7%)	60 (16.7%)	96 (26.7%)	66 (18.3%)	66 (18.3%)	12 (3.3%)
CBC	199 (55.3%)	83 (23.1%)	26 (7.2%)	21 (5.8%)	22 (6.1%)	9 (2.5%)

Table 7: Output cost composition

Cost	$80	$90	$110	$140	$180	$260
ROL output	17297	18303	27145	16973	15976	2761
Output percentage	0.18	0.19	0.28	0.17	0.16	0.03
Cumulative output	17297	35600	62745	79718	95694	98455
Cumulative percentage	0.18	0.36	0.64	0.81	0.97	1
CBC output	62592	24176	6076	4940	4856	210
Output percentage	0.61	0.24	0.06	0.05	0.05	0.002
Cumulative output	62592	86768	92844	97784	102640	102850
Cumulative percentage	0.61	0.84	0.90	0.95	0.99	1

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