Can Regulation Be Mutually Beneficial?

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Abstract

We study a buyer-seller model with both asymmetric information and market power where a seller produces a product for the buyer whose true quality cannot be ascertained without testing. We consider both an unregulated setting (in which the buyer is responsible for testing) and a regulated setting (in which sellers pay for third-party testing) and show that regulation can be mutually beneficial to both the buyer and seller. We test this theory in an experimental setting where our results show that regulation is, in fact, beneficial. Sellers' improve their payoffs by over 50% while the buyer improves her profits by almost double. Moreover, subjects recognize the beneficial effect of regulation and overwhelmingly vote for it by the end of the experiment.

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1 Introduction

Regulation – whether economic or social – touches every aspect of our lives. Although there is a resurgence in public discussions on regulation, regulatory theory has not changed significantly since the surge of research in the 1970s (Balleisen and Moss, 2009). A recent survey of regulation focuses on asymmetries of information "that arise when regulated suppliers have better information about the regulated industry than do regulators" (Armstrong and Sappington, 2007, pg. 1560). Meanwhile, Balleisen and Moss (2009) makes progress towards an updated theory to "strengthen and add to [the regulatory literature], fixing a few cracks and building from there" (Balleisen and Moss, 2009, pg. 3). We seek to add to the recent regulatory literature by introducing a new model describing a very old regulatory scheme found in agricultural marketing orders. "Marketing agreements and orders are initiated by industry to help provide stable markets for dairy products, fruits, vegetables and specialty crops. Each order and agreement is tailored to the individual industrys needs. Marketing Orders are a binding regulation for the entire industry in the specified geographical area, once it is approved by the producers and the Secretary of Agriculture." (USDA-AMS, 2019a)

In the dairy industry, producers vote-in regulations through marketing orders and the regulator tests the quality and enforces the test results for both the buyers and sellers. The Federal Milk Marketing Orders (FMMOs) began under the Agricultural Adjustment Act of 1933 (the 33 Act) and provided FMMOs the Federal authority to regulate the handling of milk. The Agricultural Marketing Agreement Act of 1937 (the 37 Act), as amended, provides the details to the authority granted under the 33 Act (Griffith, 2018). FMMOs provide a variety of services including: market information, market services, ensuring proper payments, and establishing minimum uniform prices (USDA-AMS, 2019b). While the FMMO regulation is expansive, we will only examine the impact of two services in our theory: market services (quality testing) and ensuring proper payments (enforcement).

The contribution of this paper is to use a stylized model as a lens to view the regulatory discussions based on a real-world application. Our model explains one reason as to why

FMMOs have not only survived over 80 years, but also remain a valuable regulatory scheme. Our model shows how both buyers and producers in a private goods market can improve profits under a regulatory environment as compared to a unregulated environment. This is the crux of the longevity and success of FMMOs. The simplified model we present is broad enough to see corollaries with other industries. An historically based hypothetical example is the water quality in London during the Cholera outbreak (Snow, 1855). During this time, there were multiple producers with differing qualities for buyers to buy water from. The buyers could test the water quality during the 1848-49 Cholera outbreak, but (if the technology existed) it would be costly and would only happen with a small frequency. If, hypothetically, the producers chose to self-regulate, water quality would increase and consumers' fear of contracting cholera would decrease and the self-regulated firms' profits would increase (Snow, 1855). This example illustrates how our model shows a benefit for both buyers and sellers. To this extent, we will simplify the transition from real-world regulations to a digestible theory by making several simplifying assumptions.

The main assumptions of our model are: (1) the sellers' quantity is fixed, (2) the seller chooses the quality at the beginning of the game, (3) it is a private goods market, and (4) the buyers cannot ascertain the quality without testing. In our model, we compare the payoffs for the buyers and sellers in a unregulated world (where the buyer is responsible for testing) to a regulated world (self-imposed by the sellers) where the sellers pay the regulators to test the quality. We find both the buyers' and sellers' payoffs are higher under a regulated institution.

We test our model through a controlled human-subjects experiment. In our experiment, we study behavior in the two different environments. Our first environment creates a stylized unregulated market where the participants are producers who get to choose the quality of their good and, additionally, send a cheap talk message regarding the quality.[1] This is our control treatment. Our second environment augments the control by adding a voting stage

[1] See Farrell and Rabin (1996) for lying about quality and cheap talk.

where sellers can vote to self-regulate and operate in a regulated institution or continue in an unregulated setting.

There are three main questions we want to answer. First, is there market failure under the unregulated market? Second, with regulation, does quality/profits improve? Third, will sellers recognize this and vote to self-impose regulation? We also test to see if group size impacts the results. The results show the treatment environment (i.e., in which producers can vote to self-regulate) have higher payoffs and higher true quality than the control sessions. The average sellers' profit for the control sessions increases by at least 50% regardless of the group size. Similarly the average true quality for the treatment is more than double the quality from the control sessions. Importantly we also find over 90% of the participants choose to self-regulate for the treatment sessions. For the buyers, the average payoffs under the treatment almost double from the control sessions. These results support both the model results as well as the FMMOs case study and show how a regulatory environment can help both buyers and producers. Our model adds to the theoretical regulation literature as well as the experimental regulatory literature by including a new regulatory model that does not exist in either the public interest or interest group spheres and instead provides a win-win situation for both buyers and producers through regulation.

2 Literature Review

There are two classic veins of economic regulation papers: public interest-to correct market failures-and the interest group theory (Stigler, 1971)–where the benefits are for a subset of lobbying interests. The public interest regulation theory, rooted in welfare economics, tends to assume no transaction costs and complete information (Baldwin, Cave, and Lodge, 2012). In the public interest regulatory theory, the central authority steps in to correct a market failure thereby providing a net benefit for the social welfare generally at a cost to firms. There are two main assumptions under this theory: (1) unregulated markets tend to fail due to monopolies and externalities; and (2) governments are able to fix these issues through regulations with no transaction costs. While there is no specific attributing author for the public interest theory, it is often linked to Pigou (1938) and welfare economics. This theory became the foundation and the justification for the development of regulatory policy up until the 1970s when supporters of the interest group theory gained traction. Public interest theory's two main points are: governments impose regulations (through prices, safety standards, labor markets, etc.) because unregulated markets are inherently fragile and need governments to intervene (costlessly) to ensure equitable and stable markets.

The impact of the public interest theory is seen on agriculture, utilities, broadcasting, financial markets, etc. In agriculture, the height of governmental intervention could be said was from 1930s to the 1980s for wheat, cotton, field corn, hogs, rice, tobacco, and milk products (Bowers, Rasmussen, and Baker, 1984). When parity pricing for agricultural commodities ended in 1980s, caves across the US stored governmental purchases of commodities like cheese and butter. It was in this environment, proponents of the interest group theory formed their criticisms of the public interest theory. The main criticisms are: (1) regulations are not costless; (2) government and regulators are maximizing their own interests, and not the interests of the public at large and; (3) most markets, private orderings, or courts can handle market failures without any governmental intervention (Stigler, 1971; Shleifer, 2005; Posner et al., 1974).

It is from these criticisms that Stigler's (1971) interest group theory was born, and attempts to better understand governmental regulation as enacted versus theorized. Stigler attempts to predict which industries will end up being regulated and finds the general result that special interest groups are the beneficiaries of regulatory policies. The general premise of the interest group theory simplifies regulation into supply and demand. There is a demand for regulation from special interest groups and politicians/political process provides the supply, provided the regulation supports their self-interest of re-election. Building on Stigler's (1971) article, Posner et al. (1974) attempts to provide additional case studies of Stigler's theory, although he encourages further empirical analysis of the theory. Many researchers undertook Posner's challenge to further analyze the interest group theory. Peltzman (1984) attempted to model the payoff functions to politicians for enacting a new policy. Moreover in Peltzman, Levine, and Noll (1989), they analyzed the deregulation from the 1970s and how it fit into the interest group theory. Thus swung the pendulum of economic research away from the public interest theory to the interest group theory. This period from the 1970s to the Great Recession of 2009 saw the deregulation of many industries including the transport (air, trucks, and rails) industries, financial markets, and mortgage securities, etc.

From the mid-2000s, the regulatory pendulum started to reverse and some researchers began to settle somewhere between public interest and interest group theory, believing that capitalism can only exist under sensible regulation and public officials are not always solely driven by self-interest (Shleifer, 2005; Balleisen and Moss, 2009; Djankov, Glaeser, La Porta, Lopez-de Silanes, and Shleifer, 2003). Most economists agree that without governmental assurances of property rights, capitalism would not thrive nor prosper as it has done. Shleifer (2005) introduces a different lens to categorize regulatory theory, the *Enforcement Theory of Regulation*. In his theory Shleifer extends the work of Djankov, Glaeser, La Porta, Lopez-de Silanes, and Shleifer (2003) by ranking the theories of public interest and interest group from dictatorship to disorder.[2] Economies range from disorder (no state intervention) to dictatorship (full state control) through four strategies: market discipline, private litigation, public enforcement through regulation, and state ownership. As we progress from market discipline to state ownership, control is transferred from the private citizens to the state. Enforcement theory believes that all four strategies are imperfect, recognizing there is a trade off between disorder and dictatorship, and "optimal institutional design involves a choice among these imperfect alternatives" (Shleifer, 2005, pg. 443).

This vantage point has lead the recent regulatory research to focus on the design of practical polices for regulation to combat situations such as when regulators face asymmetric

[2]Shleifer also includes a third theory, Coase's belief that courts can right any market failures if private negotiations do not work (Coase, 1960).

information while the private companies have complete information (Armstrong and Sappington, 2007). A common case includes regulators facing industries (like utilities) where the companies possess information that is not available to the regulator and how best the regulator can overcome asymmetric information (Hillier, 1997). As in our case, asymmetric information can also exist in a private good market. The lemons market is one of the most analyzed private goods market failures due to asymmetric information. Akerlof's seminal paper on the lemons market introduce the idea of giving a structure "for determining the economic costs of dishonesty" (Akerlof, 1970). Extensions of this research include insurance markets and warranty/guarantee markets. For example, Bond (1982) finds the used car market can be efficient if the buyers can eliminate some of the asymmetric information of the sellers through either warranties or information seeking. In our research we also find the elimination of asymmetric information through regulation provides a more efficient market. Our model builds on the regulatory theory and asymmetric information literature by the addition of binding self-imposed regulation for all players.

Particularly relevant to our research are previous experimental studies on voting and collective action. Putterman, Tyran, and Kamei (2011) evaluates voting and formal sanctions as a solution for the public goods game. They find that when participants are allowed to vote on formal sanctions the most efficient option is often chosen, minimizing the free-rider problem with public goods. Similarly experimental research by Kingsley (2018) and Markussen, Putterman, and Tyran (2013) analyze collective action with formal and informal sanctions. Kingsley (2018) studies how communication effects the effectiveness of central authority regimes, and finds that when the deterrence ability of the central regimes is tied to the fixed cost of the central authority, a non-deterrent central authority improves the payoffs to the players through communication. Markussen, Putterman, and Tyran (2013) finds that a central authority or formal sanctions always under-performs informal sanctions through multiple rounds of social interaction and communication. These articles provide useful insight on how the cost of a central authority can determine payoff structures as well how the social interaction can impact the efficacy of formal sanctions. We find that the participants prefer the regulated institution and experience higher payoffs under it. Our model and results are valuable additions to the current regulatory literature by showing how regulation increases payoff for both the buyer and seller.

3 Model

We start with the simple case of one producer and one buyer. The producer's quantity is fixed, but can choose the quality level. The producer chooses a quality, $q \in \{L(ow), M(edium), H(igh)\}$, and also sends a cheap talk message, $\theta \in \{\theta_l, \theta_m, \theta_h\}$, where θ_j is understood to mean "My quality is 'J'" and $J \in \{L, M, H\}$. The set of pure strategies are $P = \{L, M, H\} \times \{\theta_l, \theta_m, \theta_h\}$. Of course, it never makes sense to claim that the quality is of *lower* quality than the true quality. Therefore, we restrict attention to the following set of pure strategies: $C(S) = \{(L, \theta_l), (L, \theta_m), (L, \theta_h), (M, \theta_m), (M, \theta_h), (H, \theta_h)\}$. That is, the producer either sends a cheap talk message with the true quality or a higher quality. The sellers' payoff function is

$$\pi_S(q, \theta, \gamma) = p(q, \theta, \gamma) - c(q) \tag{1}$$

where q is the true quality, θ is the announced quality, and γ is the buyer's strategy.

Buyers are only willing to purchase the good if the quality is medium or high. The price for the different qualities are (p_l, p_m, p_h) where $p_l = 0$. The buyers know that the announced quality sent by the producer may be inaccurate. After seeing the announced quality the buyer has can pursue one of three courses of action: (i) do not test the product and do not buy (ND), (ii) do not test the product, but buy it anyway (NB) or (iii) the conditional strategy (T) of testing the product and then buying if and only if the test reports $q \in \{M, H\}$.

If the buyer does not test the product but still buys it, the price is set by the producer's announced quality. If the buyer does test the product then we assume that the buyer has sufficient power to set the price (i.e., by misreporting the outcome of the test). We assume that the buyer is able to resell the product to retailers at a price $\overline{p}_i$ where $i = l, m, h$ and reflects the true quality from selling the product to the consumer. The buyer's payoff function is

$$\pi_B(q, \theta, \gamma) = \overline{p}_i - p(q, \theta, \gamma) - f(t) \tag{2}$$

We define the testing cost, β, as

$$f(t) = \begin{cases} 0, & \text{if } t = 0 \\ \beta, & \text{if } t = 1 \end{cases}$$

We make the following assumptions are utilized in solving the model:

1. $\beta < p_h - p_m$ and $p_i + \beta < \overline{p}_i$ when $i = m, h$;

2. c_i, $\overline{p}_i$ are increasing in quality; p_i is non-decreasing in quality; and

3. $p_l = \overline{p_l} = 0$.

3.1 No Regulation

The no regulation model, as described above, represents a dynamic game of incomplete information. In Appendix A, we provide the extensive form representation of this game. Our solution concept is that of Perfect Bayesian Equilibrium (PBE). First, observe that there does not exist an equilibrium in which the producer chooses $q = H$ with probability 1. This follows because then the buyer would choose the strategy NB – buy without testing. However, with such a buyer strategy, the producer would then shirk on quality, a contradiction. Thus, the presence of asymmetric information and a positive testing cost prevent the fully efficient outcome from arising. Second, there is a trivial PBE in which the producer chooses quality $q = L$, sends any signal and the buyer chooses to never buy (ND) while believing that, after *any* message, the producer's quality is low. Third, in any PBE in which the buyer buys with positive probability, then the conditional strategy, T, must be chosen with positive probability. This follows for the same reason as our first point. Namely, if the buyer buys but never tests, then the producer would always choose low quality.

Proposition 1. *There exists a PBE in which the seller mixes between* (L, θ_m) *and* (M, θ_m)*. The buyer will prefer to mix between* T *and* NB *where there is a non-negative profit as compared to mixing between* T *and* ND *where the expected profit is 0.*

Proof. See Appendix B. □

From our previous discussion, we know the buyer will not choose a pure strategy of testing nor of not testing. When the seller announces a quality of medium, θ_m, the buyer has four potential mixed strategies: (1) mix between testing (T) and buying without testing (NB); (2) mix between testing (T) and not buying without testing (ND); (3) never test and mix between buying (NB) and not buying (ND); and (4) mix between all three options (T, ND and NB). We can discard case (3) as the probability of testing is zero, which we show does not occur; we also can rule out case (4) since it is a knife-edge case and generically not true; we discuss this further in Appendix B. We are left with the buyer either mixing between testing and not testing and either buying and not buying. With an announced quality of medium and knowing the buyer will sometimes test, the seller chooses to mix between a true quality of low and medium. For both cases (1) and (2), the buyer tests with the same probability (α) which renders the seller indifferent between low and medium true quality. Therefore, the seller will make the same choice regardless if they are in case (1) or (2). Further, the restriction on the cost of testing (β) is the same in both case (1) and (2); hence, the buyer will prefer to mix between T and NB where there is a non-negative profit as compared to mixing between T and ND where the expected profit is 0.

We now seek to understand whether there is an equilibrium in which the producer sends the signal θ_h. We have:

Proposition 2. *There exists a PBE in which the producer mixes between* (L, θ_h) *and* (M, θ_h) *and the buyer mixes between* T *and* ND*.*

Proof. See Appendix B. □

The buyer faces the same four choices as in Proposition 1. We can quickly simplify the four cases by realizing that the buyer will never choose option (1) since the buyer can, by assumption, pay a medium price to the seller (p_m), even if the test shows a high quality product. Thus the buyer is left with mixing between T and ND[3]. The producer can choose between L, M, or H as the true product quality. Since the buyer will never pay more than a medium price, the seller is better off mixing between low and medium quality.

3.2 Regulation Model

We now consider a setting in which a group of sellers independently sell to the same buyer. Before choosing their quality or sending a signal, we assume that sellers can vote for regulation. A simple majority of sellers voting for regulation will make the regulatory environment binding for all sellers. If a majority of sellers vote against regulation, then they will exist in the "Unregulated Model" from Section 3.1. To solve this model, we first consider the subgame in which the sellers have already voted in favor of a regulatory environment. Appendix A contains the extensive form for this subgame for the "regulation" model. As in the "Unregulated Model", the sellers can choose to produce a L, M, or H quality good and choose to send a cheap talk message (θ_j) with either his real quality or a higher quality. As the producers choose to have their quality tested, a central testing agency tests the product and delivers the result to both the producer and the buyer. The third-party has two functions: to test for the quality and to enforce payments based on the test.

[3]Solving the unregulated model where the buyer pays p_h when the good is tested does not change the outcome. No pure strategies exist with similar issues regarding contradicting beliefs exist as discussed in Section 2.1. The interesting case in this scenario is if mixing between medium and high quality will occur. We find this to not be the true. For example, if the seller mixes the true quality between medium and high, the buyer will only mix between T and NB if β=0, which violates our assumption of a positive testing cost. If the buyer mixes between T and ND, the seller will always produce either a medium (when the difference between the high and medium quality payoffs is non-positive) or a high (when the difference between the payoffs is positive) quality good. In this case the buyer would be better off not testing to improve profits as the seller is always producing the same quality. Once the buyer stops testing, the seller will produce low quality goods. A contradiction of beliefs.

Proposition 3. *There exists a PBE strategy at either quality M and H based on the payoffs for the seller (π_S) and buyer (π_B), which is determined by the parameters.*

Proof. See Appendix B. □

In the regulatory environment, the buyer is no longer uncertain as to which quality she is buying. Therefore, the buyer no longer risks buying a low quality good, while also not paying any testing costs. The producer no longer risks a unenforced price nor the NB scenario which increases their profits by more than the cost of testing. The sellers will produce a quality of medium or high based on the payoffs they receive, which is based on the parameters of the game (e.g., when the gain from marginal revenue minus marginal cost from selling high quality is greater than zero.). Hence, the regulatory subgame provides a more efficient market, higher quality, and higher payoffs.

Now turn to the voting stage. When players vote they face a coordination problem[4]: if all players (pessimistically) believe that everyone else will vote against regulation, then it is a best response to also oppose regulation. In contrast, sincere voting for the payoff dominant outcome will lead all players to vote in favor of regulation. Hence, we will test this empirical question in our experiment to see if the participants can overcome the coordination problem and choose the payoff-maximizing solution.

3.3 Extending the Model to Multiple Sellers

If we extend this model from one buyer and one seller to one buyer and multiple sellers we see that the buyer's decision is independent of the number of sellers; the buyer will have to make their decisions for each seller individually. As long as the buyers have more market power than an individual seller, the model for the sellers is not significantly changed either. The market power of the buyers is important as it allows the buyer under the unregulated market to pay p_m if the buyer tests and the test shows a H quality product.

[4]See Cooper, DeJong, Forsythe, and Ross (1992) and Huyck, Battalio, and Beil (1990)

For the sellers, coordination becomes an interesting empirical question as we increase the sellers from one seller to m sellers. The coordination game is relevant to the voting stage in the regulation model as the quality choice and signal sent is independent to each seller; this can lead to multiple equilibria. In the model, choosing to exist in a regulatory world is based on a simple majority and binding to all sellers, regardless of how they voted. This is an empirical question that we test in the experiment by varying the group size.

4 Experiment

We design our experiment to test if the profits and quality of those in a self-imposed regulatory environment is different than a unregulated setting. As a broad overview, each subject participates as a producer in 20 independent rounds during the experiment. There are three environment types: (1) a single-player unregulated only environment (G1), (2) three-player groups with both the regulatory and unregulated scenarios as options determined by the outcome of an initial voting stage (G3), and (3) five-player groups with both the regulatory and unregulated scenarios as options determined by the outcome of an initial voting stage (G5). We sometimes refer to environment (1) as the control with (2) and (3) as the treatment sessions. To simplify the experiment, the buyer was programmed to follow the equilibrium testing strategy. Subjects were informed that this was the case. Although the exact buyer strategy was not given, subjects were told, "The role of the buyer is played by a computer programmed to make payoff-maximizing decisions in each round. For each of the 20 rounds, the buyer's decision is not impacted by what happened in any of the previous rounds. Therefore, in each round the buyer's decision is independent of any previous or future round." We use the following parameters for the experiment as shown in Table 1.

For the control sessions the decision problem for the participants consists of which quality product to produce as well as what cheap talk message to send the buyer. The participants

	Low Quality	Medium Quality	High Quality
Seller's cost of producing product	\$0	\$2	\$3
Sale price of product (Seller's sell price)	\$0	\$10	\$15
Retail market price (Buyer's sell price)	\$0	\$12	\$17
Testing Cost	\$1.50	\$1.50	\$1.50

Table 1: Parameters (in experimental \$)

choose a low, medium or high quality product to produce. They also choose a cheap talk message of low, medium or high to send the buyer. The participants could send a cheap talk message that is either the true quality or higher than the true quality. Once the buyer is sent the cheap talk message, the buyer had the option to pay the price associated with the cheap talk message's quality or to test the product. The cost to test the product is \$1.50. If the buyer tests the product, only the buyer would know the results of the test. Therefore, the buyer would only pay the medium quality price to the producer if the quality is M or H. Figure 2 shows the payoff table we provide to the participants in the control sessions. Additionally, the buyer would test 20% of the time if the buyer sees a cheap talk message of θ_m, based on the parameters (Table 1).

Your Actions	Buyer's Possible Actions			
True Quality, Signal	Don't Test, Don't Buy	Don't Test, Buy	Test, Don't Buy	Test, Buy
Low, Low	\$0, \$0	\$0, \$0	\$0, -\$1.50,	\$0, -\$1.50
Low, Medium	\$0, \$0	\$10, -\$10	\$0, -\$1.50,	\$0, -\$1.50
Low, High	\$0, \$0	\$15, -\$15	\$0, -\$1.50,	\$0, -\$1.50
Medium, Medium	-\$2, \$0	\$8, \$2	-\$2, -\$1.50,	\$8, \$0.50
Medium, High	-\$2, \$0	\$13, -\$3	-\$2, -\$1.50,	\$8, \$0.50
High, High	-\$3, \$0	\$12, \$2	-\$3, -\$1.50,	\$7, \$5.50

Table 2: No Regulation Payoff Table

The treatment sessions differed from the control in that there is first a voting stage where the participants first decide if, as a group, they want a central authority verification of the quality; after this decision, the participants would choose the quality of the product and potentially a cheap talk message (if the group choose to operate in a unregulated setting). The two treatment sessions differed only in group size. At the beginning of each round each group's members will vote and a simple majority will either put the group in a unregulated or in a regulated setting. After each round, a new group is randomly assembled. Throughout the experiment the participants remain anonymous to the other group members. The buyer's decision is independent of the previous and future rounds. If the group votes against regulation, then each participant would follow the same process as in the control. If the group votes in favor of the regulatory institution, then the testing cost ($1.50) would be shared between all the group members equally. The quality of the product is, however, an individual seller decision. The quality choice (and thereby the payoff) for each group member is independent of the other group members. Since the test results are known by both the buyer and sellers, the buyer pays the sellers the true quality price. Table 3 shows the payoff tables we provide to the participants for institutions (2) and (3).

Your Actions	Buyer's Possible Actions			
	Group of 3		Group of 5	
True Quality	Don't Buy	Buy	Don't Buy	Buy
Low	-$0.50, $0	-$0.50, $0	-$0.30, $0	-$0.30, $0
Medium	-$2.50, $0	$7.50, $2	-$2.30, $0	$7.70, $2
High	-$3.50, $0	$11.50, $2	-$3.30, $0	$11.70, $2

Table 3: Regulation Payoff Table

University of Texas at Dallas (UTD) students were recruited to participate in this experiment in the Laboratory for Behavioral Operations and Economics (LBOE). In addition, US Department of Agriculture employees were also recruited as participants for an artefactual field experiment comparison (Carpenter, Harrison, and List, 2005), though on a smaller scale than the UTD students. In total there are 220 participants and 16 sessions. Of these, 183 participants and 13 sessions were students at the University of Texas at Dallas with the remaining from USDA employees. Due to the small sample size of the USDA employees we will discuss their results as a check on the UTD students. From UTD 3 sessions of the G1, 5 of the G3, and 5 of the G5 sessions were done. There are a total 45, 63, and 75 participants and in the individual (G1), group of three (G3), group of five (G5) experiments and it took on average 27:67, 43:02, and 39:20 minutes to complete the experiment (includes 15 minutes for the reading of the instructions and the concluding payment), respectively. Appendix C includes the experiment instructions for the three scenarios. The students were given a $5 participation fee. The experiment is programmed in SoPHIE - Software Platform for Human Interaction Experiments (Hendriks, 2019). The average earnings for the students (including the participation fee) were $12.63, $16.44, and $16.02, for G1, G3, and G5, respectively. This study was approved by the Institutional Review Board (IRB) of the University of Texas at Dallas Office of Research and Compliance.

5 Hypotheses

There are five main hypotheses we want to test. Our hypotheses follow from the main questions posed earlier. First, is there market failure under the unregulated version? Second, with regulation, does quality/profits improve? Third, will sellers recognize this and vote to self-impose regulation? In Table 4 we summarize our predictions regarding the expected payoffs for the buyer and seller for different group sizes and the expected true quality, from the hypothesis, using the parameters from Table 1. Since the true quality will potentially be a mixed strategy we assign a value of 0, 1, or 2 for low, medium and high quality, respectively. We expect there to be no high quality products in the control experiments with participants mixing between low and medium quality. For the treatment experiments (based on the parameters in Table 1), we expect only high quality products.

Option	Group Size	Expected Seller's Payoff	Expected Buyer's Payoff	Expected True Quality
Control	Individual (G1)	8	0.2	0.85
Treatment	Group of 3 (G3)	11.5	2	2
Treatment	Group of 5 (G5)	11.7	2	2

Table 4: Hypothesis Predictions for Payoffs

HYPOTHESIS 1 (H1). *The unregulated market will not result in a market failure (i.e., quality lower than would be obtained under full information).*

From Section 3 and the parameters from Table 1 we can calculate the probabilities for the buyer and seller for testing and true quality/announced quality choices. We expect the sellers, given an announced quality of θ_m, will produce a true quality of low 15% of the time and a true quality of medium 85% of the time. For **H1**, if the regulatory institution can make both the buyer and seller better off then this hypothesis will be rejected.

HYPOTHESIS 2 (H2). *Given the option, participants will vote to operate within a regulated institution.*

Our second hypothesis predicts that the participants will vote to operate within a regulated institution even though they will then incur the testing cost. This is because the regulated institution payoff dominates the unregulated institution for the sellers.

HYPOTHESIS 3 (H3). *The treatment sessions will have(a) higher true quality and (b) higher payoffs than the control sessions.*

For part (a) in our third hypothesis, we expect a higher quality choice from the treatment sessions than the control sessions. In the same vein as part (a), part (b) predicts that the participants in the treatment sessions will have higher profits than those in the control sessions. If **H2** is true, then this would naturally follow as the participants learn to maximize their payoffs over time by choosing regulation.

Hypothesis 4 (H4). *Larger group sizes will take longer to coordinate on the regulatory environment, but will result in the same general outcome of improved profits and quality for both the three and five sized groups.*

Our fourth hypothesis is that we expect the same outcome from different group sizes; although we do expect a larger group will face coordination problems, meaning that it will take them longer to converge to the payoff dominant equilibrium (i.e. the regulatory environment). The coordination problem is mitigated by spreading the testing costs over the larger group, thereby helping to facilitate the convergence to the regulatory environment.

6 Results

The results from the experiment show that the regulatory institution increases payoffs for both the sellers' and the buyer. In Section 6.1 we discuss the summary statistics for the main variables of interest and how they differ between the control and treatment sections. All the results point to significant difference between the two. In Section 6.2 we discuss participants lying tendencies and find lying occurs more frequently under the control than under the treatment conditions. Next, in Section 6.3, we look at how the participants learn over the course of the experiment and find that regardless of which section they are in, they learn to improve their payoffs in the second half as compared to the first. In Section 6.4 we provide a results summary to recap the results as they pertain to the hypotheses from section 5. Finally, in Section 6.5 we provide the results from an artefactual experiment with USDA employees.

To analyze the data we assign a 0, 1, or 2 to a low, medium, or high cheap talk message or quality choice, respectively. To test our hypotheses on outcomes, we focus on the behavior in the last half (i.e., last 10 periods) of the experiment. When discussing the participants' results, the unit of observation is each individual over the course of the experiment[5].

[5]Using a more conservative unit of observation (the session for our treatment sessions in which random matching across periods occurred) did not affect the general conclusions of the paper, albeit a slightly weaker

6.1 Summary Statistics

We first want to compare the summary statistics for the first half of the experiment to the last half of the experiment (Table 5) to see if there are any differences between them. This will help us understand the differences between the learning period (first 10 rounds) and the outcome period (last 10 rounds). If we compare the learning period and the outcome period, we see that there are noticeable differences between them. Particularly, the regulatory environment is significantly less frequent in the first half of the experiment than the last half.

In Table 5 we see the summary statistics for the first 10 rounds of the experiment under the columns F10. Even within the first 10 rounds, the differences (using a Kruskal-Wallis test) between the control and treatments are significantly different for the seller's profit and true quality.[6] However, for the announced quality and buyer profit the control and treatment are not significantly different. This could imply that even within the first ten rounds, participants adopted the regulatory option early in the experiment when given the opportunity. Furthermore, the G5 treatment lies between the G3 treatment and the control sessions. This supports the hypothesis that the larger group takes longer to move from the no regulation model to the regulation model (H4). In Table 5 we see there are not any meaningful differences for true quality and announced quality between the first 10 rounds (F10) and the last 10 rounds (L10) for the control sessions. Though the differences in profits are statistically significant, the magnitude of the difference is small, especially in comparison to the G3 and G5 treatments.

The treatment sessions present a different story. The second half of the experiment shows substantial improvements for true quality, seller profit, and buyer profit. This is accompanied by a move from 65% and 43% for adoption of a regulated environment to 92% and 91% for the

significance. Note that in the control treatment, the subject average is the appropriate unit of independent observation.

[6] The p-value for both seller's profit and true quality were less than 1%.

Group Size	True Quality		Announced Quality		Seller Profit		Buyer Profit		Regulation Adoption	
	F10	L10	F10	L10	F10	L10	F10	L10	F10	L10
G1	0.84	0.87	1.72	1.72	6.48	7.23	-1.48	-2.03	NA	NA
	(0.35)	(0.32)	(0.26)	(0.29)	(1.27)	(1.10)	(2.24)	(2.22)	NA	NA
G3	1.58	1.92	1.88	1.99	9.53	11.08	1.00	1.84	0.65	0.92
	(0.34)	(0.13)	(0.17)	(0.06)	(1.40)	(0.62)	(1.06)	(0.36)	(0.25)	(0.10)
G5	1.42	1.87	1.77	1.93	8.70	11.14	0.58	1.69	0.43	0.91
	(0.31)	(0.17)	(0.23)	(0.14)	(1.35)	(0.71)	(1.23)	(0.48)	(0.24)	(0.10)

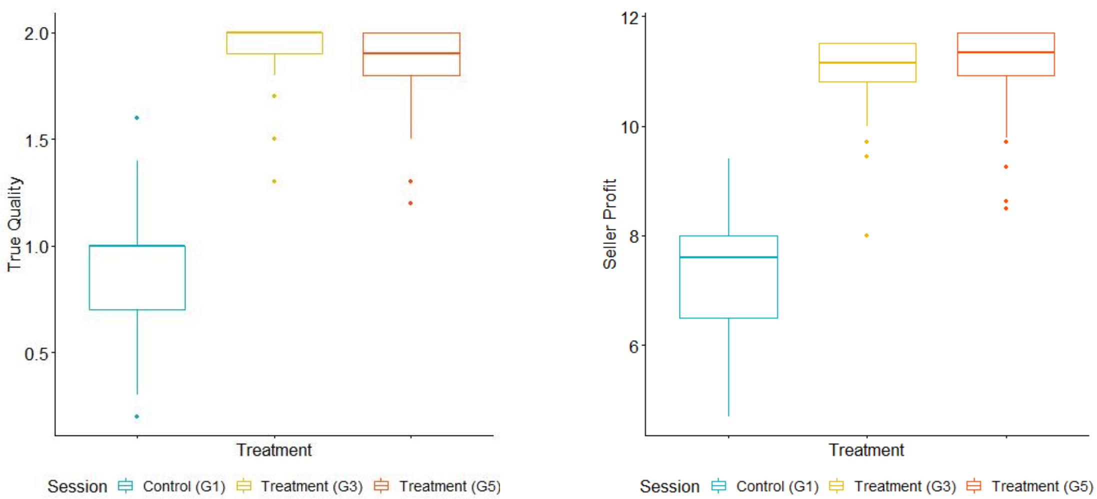
Note 1: F10 denotes the rounds 1-10 and L10 denotes the round 11-20
Note 2: Gray cells denote a paired $t-$test that is significant at less than the 5% level

Table 5: Summary Statistics

G3 and G5 treatment sessions, respectively. When we test these results using a paired t-test, we find the differences between F10 and L10 to be highly significant at the less than the 1% level. This supports our H2 hypothesis that regulation will be preferred to an unregulated setting when participants are given the opportunity to choose. The improvements in payoffs from F10 columns to L10 columns is substantial for the buyer where the payoffs increase is over 80% whereas the seller increases their payoff by close to double. We ran a paired t-test for the first half (F10) of the experiment compared to the second half (L10) for each group size (G1, G3, and G5) and found that the sellers' payoff and buyer's payoff are significant for all group sizes at the 5% significance level.[7] The quality variable is significant at less than the 1% level for the treatment (G3 and G5) sessions; however, the quality variable is not significant for the control (G1) session.

We now compare the L10 summary statistics between the group sizes. From Table 5 we see that there are noticeable differences in the variables of interest for the control (G1) and treatment sessions (G3 and G5). The payoff for the seller is over 50% higher in the treatment sessions as compared to the control sessions, whereas the buyer's payoff increases over 3 dollars in the treatment sessions as compared to the control sessions, which supports

[7]Only the buyer's payoff for the control (G1) is significant at the 5% level, all the other buyer's payoffs and all the sellers' payoffs are significant at less than the 0.1% level.



(a) True Quality

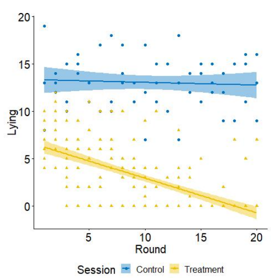
(b) Sellers' Profit

Figure 1: Quality and Sellers' Profit Comparisons for G1, G3, and G5

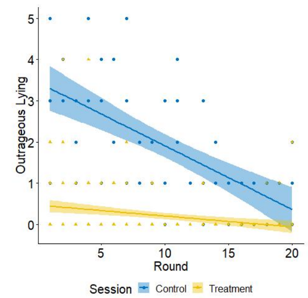
our H3 as we see higher payoffs under regulation than without. Also supporting our H3, we see that the treatment sessions true quality, in the last 10 rounds, is twice as high as the control sessions. In comparison, no noticeable difference appears to exist for the announced quality between the control and the treatment sessions. When we test these results using Kruskal-Wallis and ANOVA tests, we find the differences between the control and treatments to be highly significant at the less than the 1% level. We can visualize these results through the box plots in Figure 1. As seen in Table 5, there is no overlap visually with the control versus the treatment sessions. However, there is overlap between the G3 and G5 treatment sessions.

6.2 Lying

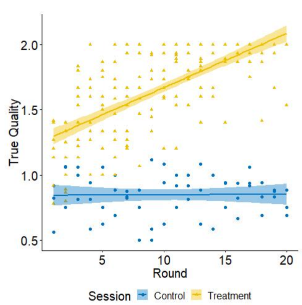
From Table 5 the control sessions' choices for quality and the cheap talk message we see the expected results of the cheap talk message being a mix between medium and high and the quality choice being a mix of low and medium. To further understand the divergence of the cheap talk message and the true quality, we analyze the frequency of lying. We define lying as announcing a higher quality than the chosen true quality. We further define an "outrageous" lie as when the true quality is low, but the participant announces a quality of high. While occasional lying under the control does improve payoffs, outrageous lying will negatively affect payoffs as the buyer will always test a high signal (see Section 3.1). At the extremes for lying in general, less than 8% of participants never lied over the course of the experiment and all of them were in the treatment sessions. Of those that never lied, 5% of the participants always voted for regulation. On the other extreme, 4% of people always lied and were exclusively in the control sessions.



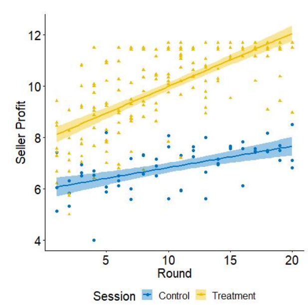
(a) Lying



(b) Outrageous lying



(c) True Quality



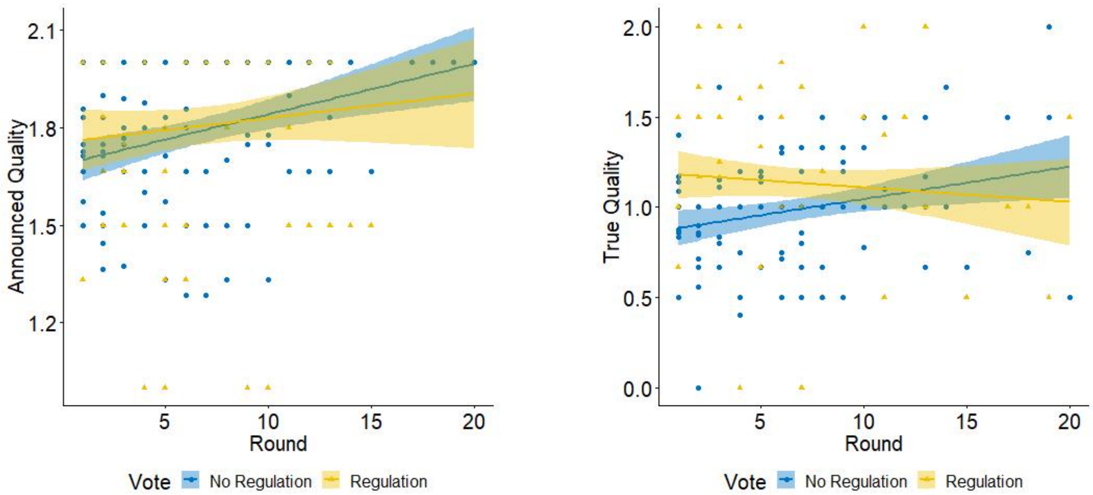
(d) Sellers' Profit

Figure 2: How Lying (a), Outrageous Lying (b), Quality (c) and Profit (d) change over the course of the experiment

If we look at how the control sessions changed over the 20 rounds, we see in Figure 2 that the general lying (2a) and the true quality (2c) remained relatively flat. Whereas we see a negative slope for the outrageous lying (2b) and a positive slope on the profits (2d). Hence, the participants are learning to lie "better" by telling fewer outrageous lies thus improving their profits without having to improve their quality or tell the truth. Numerically, the participants lie 71% in the first ten rounds versus 78% in the second ten, but the lies are less "outrageous" with a decrease from 24% in the first half to 9% in the second.

To look at the lying behavior of those participants in the treatment sessions, we see how lying differed for those participants who voted for a regulatory institution, conditional on unregulated setting being implemented (i.e., voted for by a majority of the group). This is seen in Figure 3. An important note is that in the treatment sessions, as the number of rounds increase there are fewer groups that choose to operate in a unregulated setting. In the first half there are 644 opportunities to lie (138 participants $\times$ 10 rounds $\times$ 46% of groups in the unregulated setting) whereas in the second half there are only 113 opportunities to lie (138 participants $\times$ 10 rounds $\times$ 8% of groups in the unregulated setting). Of the opportunities to lie, in the first half 66% lie; this actually increases to 73% in the second half. The "outrageousness" of the lies is approximately constant throughout the experiment around 5%.

We can break this down further into the probability of lying conditional on the participant's vote. When a participant voted *for regulation*, but found themselves in an unregulated setting, they lied about 57% of the time in the first half; this increase to 70% in the second half. For these subjects, the "outrageousness" of the lies is steady around 2% throughout. When a participant voted *for no regulation* and ended up in that very scenario, they lied around 70% in the first half which increases to around 75% in the second half. Their "outrageous" lies stay at about 6% throughout the experiment. This suggests those who voted for no regulation maintained the same behavior throughout while those who favored regulation learned to change their behavior when the participants found themselves in an unregulated setting. This suggests the participants learned how to optimize their profits over time.



(a) Announced Quality

(b) True Quality

Figure 3: Choices by G3 and G5 Group Members When the Group Chooses an "Unregulated" setting

6.3 Learning

We will now formally test whether learning is occuring over the course of the experiment. We would expect that subjects in both the control and treatment sessions learn how to better improve their payoffs as they gain experience. We also expect that the learning outcomes for the control and treatment sessions differ. From Figure 4 we see that while subjects in both the control and treatment sessions achieve higher payoffs as the experiment progresses, the subjects in the treatment sessions improve their profits better than the subjects in the control sessions. It is not only that the G3 and G5 treatment participants start at a higher value, but also that the learning rate is faster than the control participants. To test this, we estimate a random effects model of profits on round number. We also include indicator variables for session type (G1, G3, and G5) as well as interaction variables between session type and round number.

The parameter results from the random effects model with clustered standard errors are in Table 6. All the parameter estimates are positively signed. In particular, the interaction terms for G3/G5 with round are positive and significant, which indicates that learning is faster in the treatment sessions. We also see that the interaction term of $round * G5$ has a larger effect on profit than the interaction term for $round * G3$. This result is not too surprising since initially it would be harder to convince a larger group to choose a regulatory environment, but once the group "learned" to prefer a regulatory environment, their profits would increase at a quicker rate.

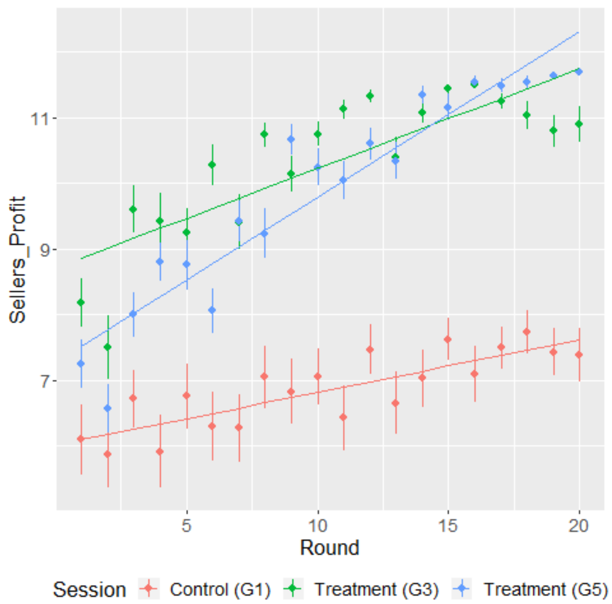


Figure 4: Learning by the different groups.

	Dependent variable:
	Sellers' Profit
Intercept	6.009*** (0.257)
Round	0.080*** (0.017)
G3	2.702*** (0.351)
G5	1.256*** (0.330)
Round*G3	0.071*** (0.022)
Round*G5	0.172*** (0.021)
Observations	4,400
R^2	0.225
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 6: Learning Estimation Results

We see similarities between profit maximization learning (Table 6) and the adoption rate of a regulatory institution (Figure 5) for G3 and G5. If we analyze the rate of adoption by the different groups (Figure 5) we see that G5 choose a regulatory institution less initially than G3. However, we see the reverse when we compare the regulatory adoption rate for G3 and G5, with G5 adopting regulations at a higher rate than G3.

We empirically test the adoption of regulation using a Kruskal-Wallis test and find for the first ten rounds the difference between G3 and G5 to be significantly different at less than a 1% level. Whereas in the second ten rounds, we find the differences between G3 and G5 are not significant. This supports our H2 where the participants will prefer to exist under a regulatory institution than without one, which they learn as they gain experience. Next we summarize the results for true quality, producer payoffs, and buyer payoffs as they pertain to the hypotheses below.

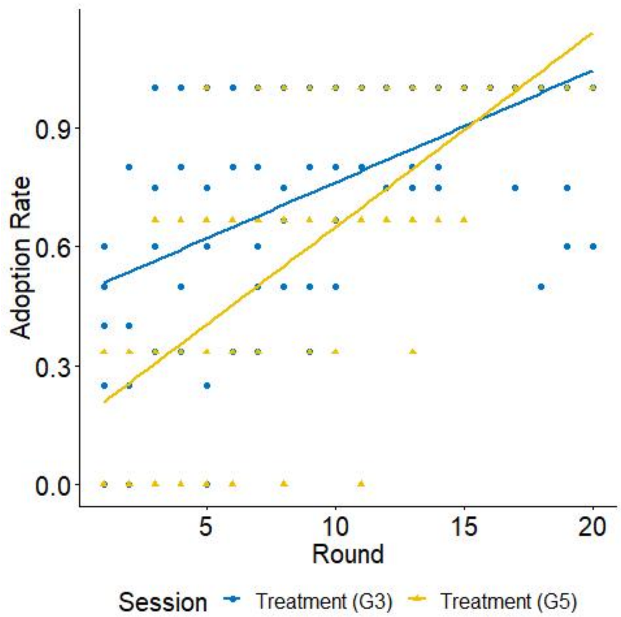


Figure 5: Percentage of Groups Choosing to Exist in a Regulatory institution over the 20 Periods

6.4 Results Summary

H1: No market failure

To analyze this hypothesis, we will look only at the control experiments to see if it ends with quality lower than under full information; that is, in a market failure. From the hypothesis section, we know that the predicted mixing between medium and low true quality should be around 85% and 15%, respectively. In the second half of the control experiments, the participants choose low quality 23% of the time, medium quality 68% of the time, and high quality 9% of the time. Additionally the producers make a profit of $7.23 under the control experiments which is similar to predicted payoffs of $8. The buyer profit under the predicted payoffs is $0.20, however under the experiments the buyer made $-2.03, which would generally indicate the buyer would exit the market. Under a regulatory institution, both the buyer and seller are better off. This hypothesis is rejected.

H2: Regulation is preferred to an unregulated market

In Figure 5 we see that the probability of participants choosing a regulatory institution increases throughout the experiment with almost all participants choosing a regulatory institution by the final round. Figure 5's visualization is supported by the statistics in Table 5 where we see the percentage of participants choosing regulation increasing from 63% and 45% in the first half of the experiment to 92% and 91% in the second half for G3 and G5, respectively. This hypothesis is verified.

H3: Higher quality (a) and payoffs (b) under regulation

If we compare the control experiments to the treatments in Table 5, we see that sellers' quality increased by more than double from an average of 0.87 to 1.92 or 1.87 for the G3 and G5 sessions, respectively. Participants in G3 experiments chose in the last ten rounds products with low quality 1% of the time, medium quality 6% of the time, and high quality 93% of the time. G5 participants chose in the second half of the experiment low quality products 1% of the time, medium quality products 11% of the time, and high quality products 88% of the time. This moves the average quality in the control experiments from mostly a mix of low and medium (but closer to medium) to, in the treatment experiments, a mix of mostly medium and high (but closer to high). The increase in quality is significant when tested using the Kruskal-Wallis and ANOVA tests at the less than 0.1%. The quality for the control session is similar to the theoretically predicted 0.85. If we compare the predicted quality for the treatment sessions for we see that the participants chose to produce a much higher quality under regulation than an unregulated market. Hypothesis 3(a) is verified.

As discussed previously and shown in Table 5, we see that sellers' and buyer's profits increase substantially. The increase for both the buyer and sellers is significant when tested using Kruskal-Wallis and ANOVA tests at the less than 1% level. If we compare the predicted profit of the control and treatment sessions for the buyer and sellers we see the actual values are close to the predicted, except for the control prediction for buyer's profit. From these results, it is easy to see the gains in payoffs under regulation for both the buyer and sellers are substantial. Hypothesis 3(b) is verified.

H4: Group size will have an impact initially, but will equalize by the end

We can look at the comparison of the different group sizes for quality, sellers' payoff, and buyer's payoffs by utilizing a Mann-Whitney test with a Bonferroni correction. As we anticipate from the summary statistics, the control and treatment sessions are all indeed significantly different for quality, sellers' payoff, and buyer's payoffs at less than the 1% level. Furthermore, the quality, sellers' profit, and buyer's profit variables between the G3 and G5 sessions are not significantly different with p-value levels of 9%, 36% and 15%, respectively . This hypothesis is verified.

From Figure 4 and 5 we see some differences in choices the groups make when they are in a G3 versus G5 scenario. Particularly, we see that the profits and regulatory adoption start off lower for the group of five members, but increase more rapidly as the experiment continues. As discussed above this was empirically tested using the Kruskal-Wallis test with there being a significant difference in choice of environment in the first ten rounds, but no significant difference for the last ten rounds.

6.5 Artefactual Field Experiment

For further analysis, USDA employees were recruited to participate. Due to the limited number of USDA participants, only one session each of the G1, G3 and G5 sessions were done. There are a total 10, 12, and 15 participants in the G1, G3, and G5 experiments and it took 26:50, 53:00, and 63:00 minutes to complete the experiment including reading the instructions, respectively. As the USDA employees participated in the experiment during regular business hours and were earning their regular wage rate, they were not compensated for their participation in keeping with Federal employee regulations.

Group Size	True Quality	Announced Quality	Seller Profit	Buyer Profit	Regulation Adoption
G1	0.84	1.44	7.03	-1.56	NA
	(0.75)	(0.50)	(3.14)	(4.87)	NA
G3	1.85	1.94	11.23	1.63	0.85
	(0.44)	(0.24)	(1.88)	(2.17)	(0.36)
G5	1.77	1.88	10.65	1.51	0.77
	(0.47)	(0.35)	(2.42)	(1.63)	(0.42)

Table 7: Summary Statistics of USDA Experiments, Rounds 11-20

The USDA employees did the same experiment as the UTD students and were not informed on how the experiment related to their work. The USDA employees job functions included: auditor, laboratory technician, dairy scientist, administrative assistant, economist/statistician, human resources, accountant, and management. From the summary statistics in Table 7, we see the results are less pronounced when compared to the UTD students; however the general theme still holds with a high adoption of the regulated environment improving sellers' profit, buyer's profit and true quality. The adoption rate in the artefactual field experiment is greater than 75%. The lower adoption rate tracks with the lower seller profits under the treatment sessions. Additional field experiments (both artefactual and framed) would help to substantiate these findings.

7 Conclusion

The double-edged sword of regulatory theory produces winners and losers. We propose a model where regulation is beneficial for both the buyer and sellers. Our results show (both theoretically and experimentally) that regulation can be beneficial to all parties involved, given the right conditions. Our main assumptions of the model are: (1) a private-goods market, (2) asymmetric information by the seller, (3) quantity is fixed and (4) quality is chosen by the producer. Our model predicts that when there exists asymmetric information on the part of the seller and potential price manipulation on the part of the buyer, both the buyer and sellers receive higher payoffs under self-imposed regulation. We test our model through a lab experiment and find that both the buyer's and sellers' payoffs increase by at least 50% and the true quality of the good doubles.

In our experiment, our control sessions are the unregulated setting. For our treatment sessions, the participants are sorted into random groups for each round and vote on either an unregulated or a regulated setting. The treatment results show large improvements for both the sellers and buyer as compared to the control sessions. Furthermore, by the second half of the treatment sessions the participants overwhelmingly choose to exist in a regulated institution with over 90% of the groups being regulated.

As the value and harm of regulation is once again hotly debated, it is important to consider new theories of regulation and its impacts on the players. This model is based on a real-life application from agriculture and Federal Milk Marketing Orders (FMMOs) which congress legislated in the 1930s and are still in existence. FMMOs provide binding regulation that are voted in by producers and impact both the producers and buyers. A large reason for FMMO success for over 80 years, is that both buyers and sellers benefit from the regulation, which our model and experiment formally theorize and test.

Our model shows how removing the asymmetric information through self-imposed regulation from the sellers can provide benefits for all. For simplicity we computerized the buyer's choices based on payoff maximizing decisions; however, future work could look at running the experiment with both buyer and sellers as participants. Future work could also explore an in-depth artefactual and framed field experiments with those that are currently working in FMMOs. Additionally removing the price manipulation condition, which was done to simplify the model, would also provide further insight into this regulatory model.

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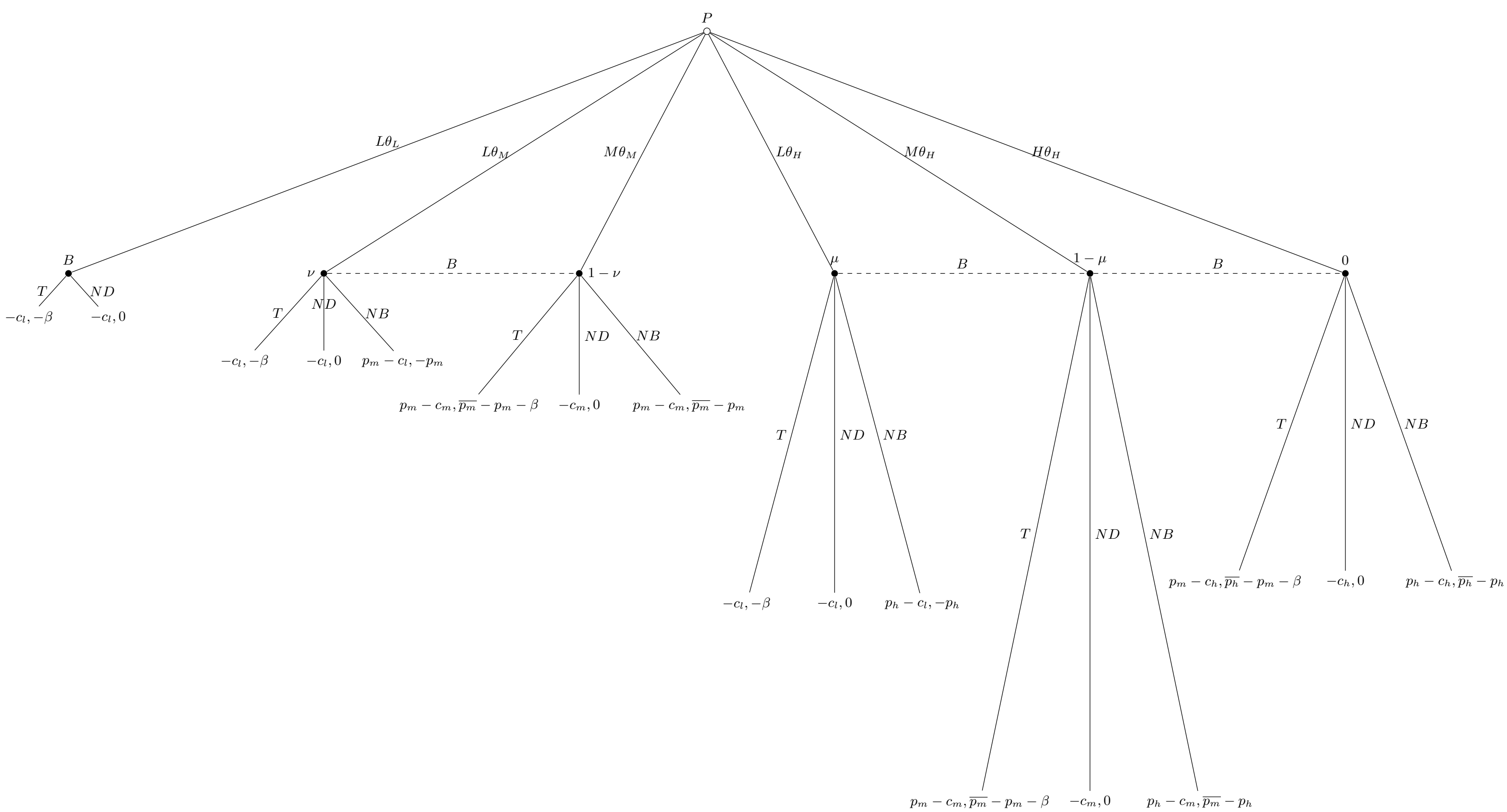
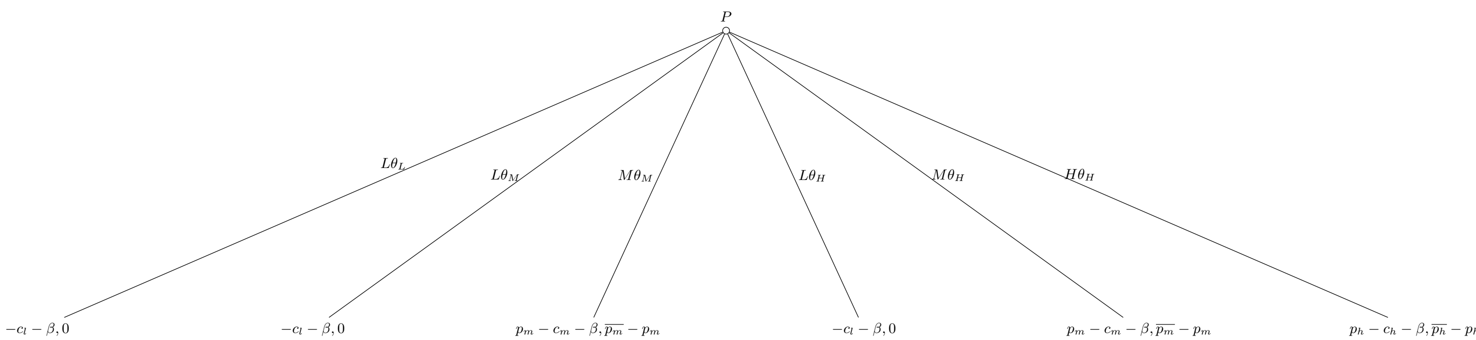
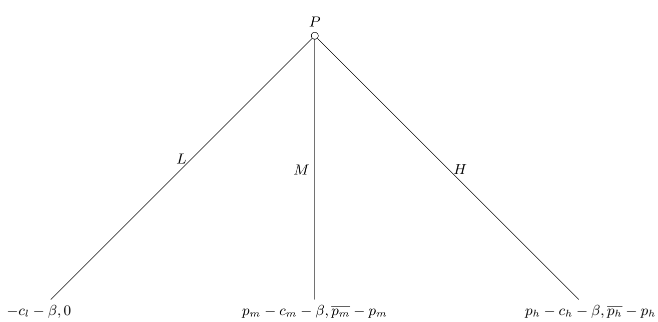
A Extensive Form



Model 1: No Regulation



Model 2: With Regulation and a Signal



Model 3: With Regulation and no Signal

B Proofs

Proposition 1: Buyer sees θ_m

Proof. There are four cases regarding the buyer's strategy that we must consider: (Case 1) buyer mixes between T and NB; (Case 2) buyer mixes between T and ND; (Case 3) buyer mixes between ND and NB; and (Case 4) buyer mixes between T, ND and NB. Let ν be the probability that the producer chooses quality L and $1-\nu$ is the probability of choosing quality M.

Case 1: Buyer mixes between T and NB. In this case the buyer must be indifferent between T and NB, and must prefer both to ND. Observe that ND yields a payoff of 0 to the buyer. The expected payoff to T and NB are, respectively $\mathbb{E}[\pi_b(T)] = \nu(-\beta) + (1-\nu)(\overline{p}_m - p_m - \beta)$ and $\mathbb{E}[\pi_b(NB)] = \nu(0) + (1-\nu)\overline{p}_m - p_m$. Setting these equal and solving for ν yields:

$$\nu = \frac{\beta}{p_m}.$$

Observe that for this to be an equilibrium, the buyer must get non-negative expected profits. That is, the testing cost, β, must satisfy:

$$\beta \leq p_m - \frac{p_m^2}{\overline{p}_m}.$$

We also require the producer to be indifferent between L and M and preferred to H or any other signal. We are free to specify off-equilibrium beliefs as we see fit, so we assume that the buyer believes that quality is L following any other signal. With these beliefs, a buyer will clearly not send any other signal. Furthermore, since the buyer signaled θ_m, they can never benefit by choosing high quality since they will never get the price for high quality. Let α denote the probability that the buyer chooses T. Then $\mathbb{E}[\pi_p(L)] = \alpha(-c_l)+(1-\alpha)(p_m-c_l)$

and $\mathbb{E}[\pi_p(M)] = p_m - c_m$. Setting these two equal and solving for α yields:

$$\alpha = \frac{c_m - c_l}{p_m}.$$

Thus, provided that the cost of testing is sufficiently low, this identifies a PBE.

Case 2: Buyer mixes between T and ND. In this case, we require $\mathbb{E}[\pi_b(T)] = 0 \geq \mathbb{E}[\pi_b(NB)]$. Solving $\mathbb{E}[\pi_b(T)] = \nu(-\beta) + (1-\nu)(\overline{p}_m - p_m - \beta) = 0$ yields,

$$\nu = 1 - \frac{\beta}{\overline{p}_m - p_m}.$$

Substituting the value of ν into the expression for $\mathbb{E}[\pi_b(NB)]$, and imposing that it must be non-positive yields:

$$\beta > \frac{(\overline{p}_m - p_m)^2}{\overline{p}_m}.$$

However, we must also ensure that $\nu \in [0,1]$. This requires the further restriction that $\beta \in (0, \overline{p}_m - p_m)$.

We also require the producer to be indifferent between L and M and preferred to H or any other signal. We are free to specify off-equilibrium beliefs as we see fit, so we assume that the buyer believes that quality is L following any other signal. With these beliefs, a buyer will clearly not send any other signal. Furthermore, since the buyer signaled θ_m, they can never benefit by choosing high quality since they will never get the price for high quality. Let α denote the probability that the buyer chooses T. Then $\mathbb{E}[\pi_p(L)] = -c_l$ and $\mathbb{E}[\pi_p(M)] = \alpha(p_m) - c_m$. Setting these two equal and solving for α yields:

$$\alpha = \frac{c_m - c_l}{p_m}.$$

Thus, provided that the cost of testing is in the appropriate range, this identifies a PBE.

Case 3: Buyer mixes between NB and ND. Notice that we can immediately rule out this case. With no threat of testing, the producer will strictly prefer to produce low quality since $c_l < c_m$. Therefore, there is no PBE in which the buyer mixes between NB and ND.

Case 4: Buyer mixes between T, NB and ND. In this case, we need $\mathbb{E}[\pi_b(T)] = \mathbb{E}[\pi_b(NB)] = \mathbb{E}[\pi_b(ND)] = 0$. That is, from Case 2:

$$\nu = 1 - \frac{\beta}{\overline{p}_m - p_m},$$

while from Case 1:

$$\nu = \frac{\beta}{p_m}.$$

Setting these equal yields:

$$\beta = \frac{(\overline{p}_m - p_m)p_m}{\overline{p}_m}.$$

Notice that this is not generically true. Thus, this represents a knife-edge case, which we do not consider.

□

Proposition 2: Buyer sees θ_h

Proof. In seeking to characterize such an equilibrium, we first assume that if the buyer receives any other signal other than θ_h, that she will believe quality is low and not buy. Therefore, this ensures that the producer will never send a lower signal. Notice also that the buyer has an additional incentive to test. If she does not test, but decides to buy, then she must pay p_h, while if she does test and buys, then she will only pay p_m. Furthermore, since $\beta < p_h - p_m$ (by assumption), the buyer will never choose NB as it is dominated by T.

Next, observe that because the buyer never chooses NB, the producer will never choose high quality because it is more costly to produce than medium quality and the producer will never be rewarded with a higher price. Given this, the only case that remains is where the producer mixes between L and M and the buyer mixes between T and ND. This corresponds exactly to Case 2 from Proposition 1.

□

Proposition 3: Buyer chooses regulation

Proof. The PBE strategy depends on the payoff differences between the sell price and the buy price for the buyer ($\overline{p_h} - p_h$ versus $\overline{p_m} - p_m$). For the producer it depends on the payoff differences between the sell price and the cost of producing the good ($p_h - c_h$ versus $p_m - c_m$). A high quality product is an achievable equilibrium as long as both the producer and buyer have weakly increasing payoffs in quality. Unlike in the free market model, a low quality product is dominated by both the medium and high quality strategies. Incorporating a cheap talk message is a trivial exercise as the product is tested every time which is what determines the price and the cheap talk has no impact the payoffs. Therefore we can reduce a regulation model with a cheap talk message from a six outcome game to a three outcome game where the options are for the producer to only choose a L, M, or H quality and not send any cheap talk messages. □

C Experimental Instructions

Instructions

Thank you for agreeing to take part in this experiment. You are about to participate in a decision-making experiment. Please do not talk with any other participant, and do not use any resources outside of those given to you during the experiment.

Game Overview

In this experiment, you will make decisions in each of 20 independent rounds. Throughout the experiment, we will denote payoffs in terms of **experimental dollars ($)**.

In each round, you will play the role of a **seller** selling a product to a buyer. As a seller you can choose to sell either a high, medium, or low quality product. While you know the true quality of the product, the buyer cannot ascertain the quality without testing it. In addition to choosing a quality level, you also simultaneously send a signal to the buyer, which is the quality you claim the product to be. The signal can be either the true quality or higher than the true quality. As a seller your payoff from each round is the difference between the sale price of the product and your cost of producing the true quality that you choose. The sale price of the product will depend on the signal you send or on whether the buyer decides to test. You are trying to maximize your final payoff, which is the sum of the payoffs from the 20 rounds. Your final payoff will be based on your decisions, the decisions of the buyer, and possibly chance.

The role of the buyer is computerized. Details on how the buyer makes decisions are given after discussing the seller's decisions.

Seller's Decisions

In each round you make two decisions: You choose the quality of the product (low, medium, or high) you are selling <u>and</u> a signal (low, medium, or high) to send to the buyer. You will incur a cost to produce the product; the cost incurred increases with the quality of the product. While it is more costly to produce a higher quality, the price the buyer will pay for the product is higher the higher the quality. The net payoffs for the different options are displayed in the Payoff Table. Remember the signal will be either the true quality or higher than the true quality. As the seller you can choose one of the following combination pairs (as shown below).

Seller choice options for a (True Quality, Signal) Pair

True Quality	Signal
Low	Low
Low	Medium
Low	High
Medium	Medium
Medium	High
High	High

Buyer's Decisions

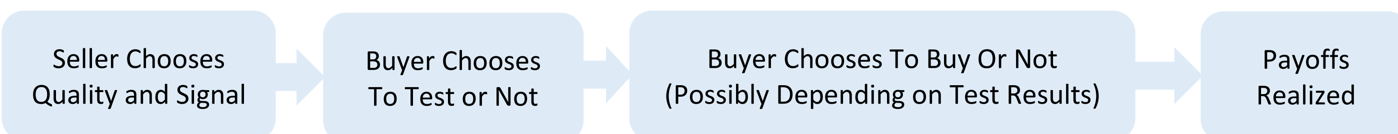
The role of the buyer is played by a computer programmed to make payoff-maximizing decisions in each round. For each of the 20 rounds, the buyer's decision is not impacted by what happened in any of the previous rounds. Therefore, in each round the buyer's decision is independent of any previous or future round.

For each round, once you make your selection of the (True Quality, Signal) pair, the buyer (computer) will make an **optimal** choice. The buyer cannot immediately observe the true quality of your product. However, the buyer can choose to test the product for the product quality by paying a testing cost of **$1.50**. The buyer must also decide about whether to buy the product or not.

If the buyer decides to buy the product then the price paid to you will be determined by the signal you reported if the buyer **does not test**. However, if the buyer **does test and decides to buy**, then the buyer will pay a fixed price, irrespective of the signaled or tested quality. Note that the buyer will never buy following a signal of low quality or a test revealing low quality.

Timing of Events

The sequence of events is summarized as follows:



Payoff Table

We can summarize the payoff consequences of any pair of actions by you (the seller) and the buyer as follows. The first number in each cell represents your payoffs, while the second number in each cell represents the payoffs of the buyer.

Your Actions	Buyer's Action Possible Actions			
True Quality, Signal	**Don't Test, Don't Buy**	**Don't Test, Buy**	**Test, Don't Buy**	**Test, Buy**
Low, Low	$0 , $0	$0 , $0	$0 , -$1.50	$0 , -$1.50
Low, Medium	$0 , $0	$10 , -$10	$0 , -$1.50	$0 , -$1.50
Low, High	$0 , $0	$15 , -$15	$0 , -$1.50	$0 , -$1.50
Medium, Medium	-$2 , $0	$8 , $2	-$2 , -$1.50	$8 , $0.50
Medium, High	-$2 , $0	$13 , -$3	-$2 , -$1.50	$8 , $0.50
High, High	-$3 , $0	$12 , $2	-$3 , -$1.50	$7 , $5.50

For example, if you choose **(Medium, High)** and the buyer chooses **(Don't Test, Buy)**, then you will receive 13 experimental dollars and the buyer will receive –3 experimental dollars.

At the end of each round, you will see the decisions of both the buyer and the seller as well as the payoffs earned by each player. This concludes one round. In total, you will play for 20 independent rounds. Remember, for the buyer each round is independent of the other. Therefore, a decision made in this round has no impact on any future rounds.

Your final payoff will be determined by the sum of earnings over all 20 rounds. We will convert your total in experimental dollars to US dollars at the rate of **1 USD = 18 Experimental dollars**. This will be added to your $5 show-up fee and paid at the end of the experiment.

Instructions

Thank you for agreeing to take part in this experiment. You are about to participate in a decision-making experiment. Please do not talk with any other participant, and do not use any resources outside of those given to you during the experiment.

GAME OVERVIEW

In this experiment, you will make decisions in each of 20 independent rounds. Throughout the experiment, we will denote payoffs in terms of **experimental dollars ($)**.

In each of 20 rounds, you will be one of 3 sellers in a market, each of whom sell a product to the same buyer. The product that you wish to sell can be either low, medium, or high quality, depending on the quality level you choose. While you know the quality of your product, the buyer cannot know the quality for certain without the product being tested.

Before choosing the quality, you and the other two sellers must decide which party is responsible for testing – the buyer or the sellers. The scenario that will be applied will be based on what the majority of the **sellers** decide. The scenario that the majority choose, will be effective for all three sellers. **DO NOT TALK** to any other participant. Once the sellers have all voted, you will be notified of the result.

Scenario 1: Buyer Responsible for Testing

This scenario occurs if 2 or more sellers vote that the buyer should be responsible for testing. As a seller you can choose to sell either a high, medium, or low quality product. While you know the true quality of the product, the buyer cannot ascertain the quality without testing it. In addition to choosing a quality level, you also simultaneously send a signal to the buyer, which is the quality you claim the product to be. The signal can be either the true quality or higher than the true quality. As a seller your payoff from each round is the difference between the sale price of the product and your cost of producing the true quality that you choose. The sale price of the product will depend on the signal you send or on whether the buyer decides to test. You are trying to maximize your final payoff, which is the sum of the payoffs from the 20 rounds. Your final payoff will be based on your decisions, the decisions of the buyer, and possibly chance.

The role of the buyer is computerized. Details on how the buyer makes decisions are given after discussing the seller's decisions.

Seller's Decisions

In each round you make two decisions: You choose the quality of the product (low, medium, or high) you are selling <u>and</u> a signal (low, medium, or high) to send to the buyer. You will incur a cost to produce the product; the cost incurred increases with the quality of the product. While it is more costly to produce a higher quality, the price the buyer will pay for the product is higher the higher the quality. The net payoffs for the different options are displayed in the Payoff Table in this section. Remember the signal will be either the true quality or higher than the true quality. As the seller you can choose one of the following combination pairs (as shown below).

Seller choice options for a (True Quality, Signal) Pair

True Quality	Signal
Low	Low
Low	Medium
Low	High
Medium	Medium
Medium	High
High	High

Buyer's Decisions

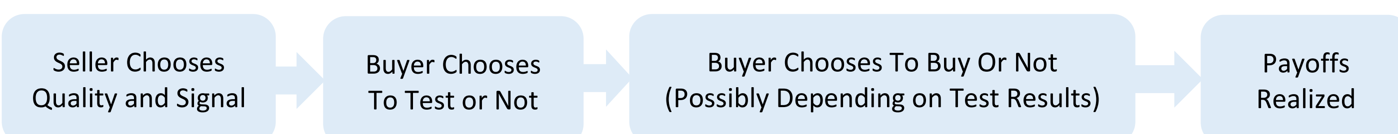
The role of the buyer is played by a computer programmed to make payoff-maximizing decisions in each round.

For each round, once you make your selection of the (True Quality, Signal) pair, the buyer (computer) will make an **optimal** choice. The buyer cannot immediately observe the true quality of your product. However, the buyer can choose to test the product for the product quality by paying a testing cost of **$1.50**. The buyer must also decide about whether to buy the product or not.

If the buyer decides to buy the product then the price paid to you will be determined by the signal you reported if the buyer **does not test**. However, if the buyer **does test and decides to buy**, then the buyer will pay a fixed price, irrespective of the signaled or tested quality. Note that the buyer will never buy following a signal of low quality or a test revealing low quality.

Timing of Events

The sequence of events is summarized as follows:



Payoff Table

We can summarize the payoff consequences of any pair of actions by you (the seller) and the buyer as follows. The first number in each cell represents your payoffs, while the second number in each cell represents the payoffs of the buyer.

Your Actions	Buyer's Action Possible Actions			
True Quality, Signal	**Don't Test, Don't Buy**	**Don't Test, Buy**	**Test, Don't Buy**	**Test, Buy**
Low, Low	$0 , $0	$0 , $0	$0 , -$1.50	$0 , -$1.50
Low, Medium	$0 , $0	$10 , -$10	$0 , -$1.50	$0 , -$1.50
Low, High	$0 , $0	$15 , -$15	$0 , -$1.50	$0 , -$1.50
Medium, Medium	-$2 , $0	$8 , $2	-$2 , -$1.50	$8 , $0.50
Medium, High	-$2 , $0	$13 , -$3	-$2 , -$1.50	$8 , $0.50
High, High	-$3 , $0	$12 , $2	-$3 , -$1.50	$7 , $5.50

For example, if you choose **(Medium, High)** and the buyer chooses **(Don't Test, Buy)**, then you will receive 13 experimental dollars and the buyer will receive –3 experimental dollars.

After all choices have been made, you will see the decisions of both the buyer and the seller as well as the payoffs earned by each player. This concludes the round.

Scenario 2: Sellers Responsible For Testing

This scenario occurs if 2 or more sellers vote that the sellers should be responsible for testing. As a seller you can choose to sell either a high, medium, or low quality product. The group of sellers will pay an independent third party to test the product and report the quality of each seller to both the sellers and the buyer. As a seller your payoff from each round is the sale price of your product quality minus your cost of producing the true quality that you choose minus the testing cost divided by 3 (see the Payoff Table below for more information). The cost for each seller to test the product for the product quality is **$0.50 or $1.50 divided by 3 (the number of group members)**. The test results will determine the sale price of the product.

The role of the buyer is computerized. Details on how the buyer makes decisions are given after discussing the seller's decisions.

Seller's Decisions

In each round you must choose the quality of the product (low, medium, or high) you are selling. You will incur a cost to produce the product; the cost incurred increases with the quality of the product. While it is more costly to produce a higher quality, the price the buyer will pay for the product is higher the higher the quality. The net payoffs for the different options are displayed in the Payoff Table in this section. As the seller you can choose one of the following qualities:

Seller quality choice options

True Quality
Low
Medium
High

Buyer's Decisions

The role of the buyer is played by a computer programmed to make payoff-maximizing decisions in each round.

For each round, once you make your quality selection, the buyer (computer) will make an **optimal** choice. The buyer knows the true quality of your product due to the independent test and will pay the sale product price based on the test. The buyer will purchase the product as long as the quality is medium or high; the buyer will not purchase low quality.

Timing of Events

The sequence of events is summarized as follows:

Seller Chooses Quality → Independent Test Provided to Buyer → Buyer Chooses To Buy Or Not → Payoffs Realized

Payoff Table

We can summarize the payoff consequences of any pair of actions by you (the seller) and the buyer as follows. The first number in each cell represents your payoffs, while the second number in each cell represents the payoffs of the buyer.

	Buyer's Action Possible Actions	
Your Action (True Quality)	**Don't Buy**	**Buy**
Low	-$0.50 , $0	-$0.50 , $0
Medium	-$2.50 , $0	$7.50 , $2
High	-$3.50 , $0	$11.50 , $2

For example, if you choose **(Medium)** and the buyer chooses **(Buy)**, then you will receive 7.5 experimental dollars and the buyer will receive 2 experimental dollars.

After all choices have been made, you will see the decisions of both the buyer and the seller as well as the payoffs earned by each player. This concludes the round.

Final Notes

In total, you will play for 20 independent rounds. In each round, you and the sellers in your group first determine which party will be responsible for testing. Depending on the vote, the round will proceed according to one of the above scenarios.

Remember, for the buyer each round is independent of the other. Therefore, a decision made in this round has no impact on any future rounds.

At the start of each round, you are randomly placed in a group of with two other sellers.

Your final payoff will be determined by the sum of earnings over all 20 rounds. We will convert your total in experimental dollars to US dollars at the rate of **1 USD = 18 Experimental dollars**. This will be added to your $5 show-up fee and paid at the end of the experiment.

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GAME OVERVIEW

In this experiment, you will make decisions in each of 20 independent rounds. Throughout the experiment, we will denote payoffs in terms of **experimental dollars ($)**.

In each of 20 rounds, you will be one of 5 sellers in a market, each of whom sell a product to the same buyer. The product that you wish to sell can be either low, medium, or high quality, depending on the quality level you choose. While you know the quality of your product, the buyer cannot know the quality for certain without the product being tested.

Before choosing the quality, you and the other four sellers must decide which party is responsible for testing – the buyer or the sellers. The scenario that will be applied will be based on what the majority of the **sellers** decide. The scenario that the majority choose, will be effective for all five sellers. **DO NOT TALK** to any other participant. Once the sellers have all voted, you will be notified of the result.

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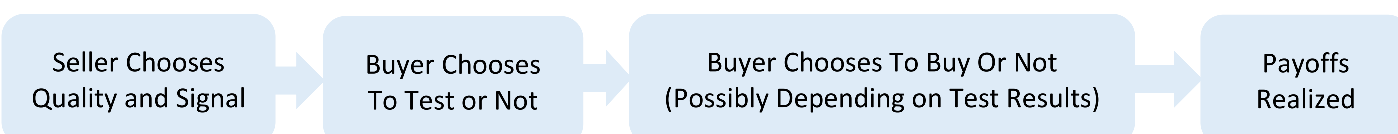

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Low, Medium	$0 , $0	$10 , -$10	$0 , -$1.50	$0 , -$1.50
Low, High	$0 , $0	$15 , -$15	$0 , -$1.50	$0 , -$1.50
Medium, Medium	-$2 , $0	$8 , $2	-$2 , -$1.50	$8 , $0.50
Medium, High	-$2 , $0	$13 , -$3	-$2 , -$1.50	$8 , $0.50
High, High	-$3 , $0	$12 , $2	-$3 , -$1.50	$7 , $5.50

For example, if you choose **(Medium, High)** and the buyer chooses **(Don't Test, Buy)**, then you will receive 13 experimental dollars and the buyer will receive –3 experimental dollars.

After all choices have been made, you will see the decisions of both the buyer and the seller as well as the payoffs earned by each player. This concludes the round.

Scenario 2: Sellers Responsible For Testing

This scenario occurs if 3 or more sellers vote that the sellers should be responsible for testing. As a seller you can choose to sell either a high, medium, or low quality product. The group of sellers will pay an independent third party to test the product and report the quality of each seller to both the sellers and the buyer. As a seller your payoff from each round is the sale price of your product quality minus your cost of producing the true quality that you choose minus the testing cost divided by 5 (see the Payoff Table below for more information). The cost for each seller to test the product for the product quality is **$0.30 or $1.50 divided by 5 (the number of group members)**. The test results will determine the sale price of the product.

The role of the buyer is computerized. Details on how the buyer makes decisions are given after discussing the seller's decisions.

Seller's Decisions

In each round you must choose the quality of the product (low, medium, or high) you are selling. You will incur a cost to produce the product; the cost incurred increases with the quality of the product. While it is more costly to produce a higher quality, the price the buyer will pay for the product is higher the higher the quality. The net payoffs for the different options are displayed in the Payoff Table in this section. As the seller you can choose one of the following qualities:

Seller quality choice options

True Quality
Low
Medium
High

Buyer's Decisions

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For each round, once you make your quality selection, the buyer (computer) will make an **optimal** choice. The buyer knows the true quality of your product due to the independent test and will pay the sale product price based on the test. The buyer will purchase the product as long as the quality is medium or high; the buyer will not purchase low quality.

Timing of Events

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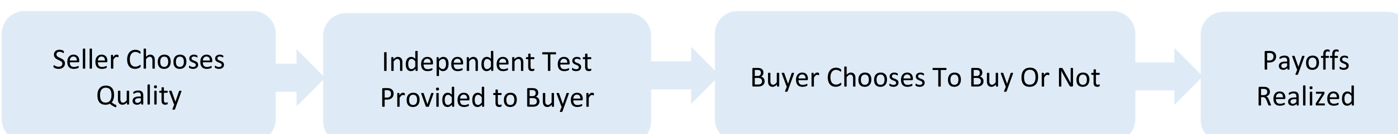

Payoff Table

We can summarize the payoff consequences of any pair of actions by you (the seller) and the buyer as follows. The first number in each cell represents your payoffs, while the second number in each cell represents the payoffs of the buyer.

	Buyer's Action Possible Actions	
Your Action (True Quality)	**Don't Buy**	**Buy**
Low	-$0.30 , $0	-$0.30 , $0
Medium	-$2.30 , $0	$7.70 , $2
High	-$3.30 , $0	$11.70 , $2

For example, if you choose **(Medium)** and the buyer chooses **(Buy)**, then you will receive 7.70 experimental dollars and the buyer will receive 2 experimental dollars.

After all choices have been made, you will see the decisions of both the buyer and the seller as well as the payoffs earned by each player. This concludes the round.

Final Notes

In total, you will play for 20 independent rounds. In each round, you and the sellers in your group first determine which party will be responsible for testing. Depending on the vote, the round will proceed according to one of the above scenarios.

Remember, for the buyer each round is independent of the other. Therefore, a decision made in this round has no impact on any future rounds.

At the start of each round, you are randomly placed in a group of with four other sellers.

Your final payoff will be determined by the sum of earnings over all 20 rounds. We will convert your total in experimental dollars to US dollars at the rate of **1 USD = 18 Experimental dollars**. This will be added to your $5 show-up fee and paid at the end of the experiment.