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Truth-telling and trust in sender-receiver games with intervention

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Abstract. Recent experimental studies find excessive truth-telling in strategic information transmission games with conflictive preferences. In this paper, we show that this phenomenon is more pronounced in sender-receiver games where a truthful regulator randomly intervenes. We also establish that intervention significantly increases the excessive trust of receivers.

Keywords: Strategic information transmission, truth-telling, trust, sender-receiver game.

JEL Classification Numbers: C72, C90, D83

1 Introduction

In their seminal work, Crawford and Sobel (1982) introduce and study strategic information transmission between two parties who have aligned or conflictive

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interests.[1] They assume that a better informed party (sender) transmits a non-verifiable and costless message to the other party (receiver) who then takes a payoff relevant action. Their results show that (i) as the (nonconflictive) interests of the two parties become less aligned, less information is transmitted, and (ii) if interests of the two parties diverge even by an arbitrarily small amount, no information is transmitted.

Of the two theoretical predictions of Crawford and Sobel (1982), prediction (i) is supported by Dickhaut et al. (1995) in their pioneering experimental paper on strategic information transmission, and later by Cai and Wang (2006), who also show that senders are more truthful whereas receivers are more trustful than what the theory predicts in the most informative sequential equilibrium. Cai and Wang (2006) explain this overcommunication phenomenon using a behavior type analysis (see for example Stahl and Williams, 1994, 1995; Nagel, 1995; Costa-Gomes et al., 2001; and Crawford, 2003 among others) and quantal response equilibrium concept (McKelvey and Palfrey, 1995, 1998).

A recent strand of experimental literature studies the second theoretical prediction of Crawford and Sobel (1982). As such, Gneezy (2005) shows that in a sender game where the preferences are conflictive but only the sender knows the payoff structure, the probability of lying is higher, the higher is the resulting gain to the sender or the lower is the resulting loss to the receiver. Sánchez-Pagés and Vorsatz (2007) consider a sender-receiver game where the sender who observes the true state of the world can choose to tell the truth or to lie whereas the receiver can trust or distrust. They establish in their baseline game that when preferences are conflictive but not too unequal, senders tell the truth significantly more frequently than predicted by the cheap-talk equilibrium consistent with purely material incentives. To understand the non-material roots underlying this phe-

[1] Among many economic environments, information exchange in Cournot duopolies (Novshek and Sonnenschein, 1982), legislative relationships between committees and floors (Gilligan and Krehbiel, 1987), grade inflation and letters of recommendation for the promotion of college graduates (Rosovsky and Hartley, 2002), communication between biased securities analysts and investors (Blanes i Vidal, 2003), doctor-patient relationships (Kőszegi, 2006) are some studied examples that allow for incentives for strategic information transmission.

nomenon, Sánchez-Pagés and Vorsatz (2007) design a punishment game which permits the receiver to costly punish the sender once the outcome of the baseline game is observed. Thus they are able to show that excessive truth-telling in the baseline game can be explained in terms of normative social behavior. In a similar setup, Sánchez-Pagés and Vorsatz (2009) further show that when the sender is also allowed to choose a costly option of remaining silent, excessive truth-telling observed in the benchmark game can be attributed to lying aversion. Peeters et al. (2008) deal with the same phenomenon of excessive truth-telling from a different angle again with the help of two related games. While a baseline game is designed as similarly to those in Sánchez-Pagés and Vorsatz (2007, 2009), a reward game allows the receiver to give a reward of a fixed amount to the sender once the baseline game was played and the histories were observed by the players. Peeters et al. (2008) find that in the baseline game senders tell the truth significantly more often than, whereas receivers trust almost as often as, predicted by the theory. Moreover, the excessive truth-telling disappears under the rewarding environment, while the trust frequency increases significantly.

In this paper, we aim to contribute to the above literature, dealing with prediction (ii) of Crawford and Sobel (1982), by studying the robustness of excessive truth-telling phenomenon with respect to the random intervention of a truthful regulator in situations where the transfer of strategic information is under some degree of control. This modified game with the random intervention of a regulator is equivalent to a behavioral game in which a sender can be of either a strategic (standard rational) type or a behavioral (honest) type, with the probability distribution over the types being common knowledge.[2] An example of

[2]In this regard, our experimental paper is closely related to the theoretical model of Landi and Colucci (2008), where there is uncertainty about both sender's and receiver's types. In that model, each player belongs to a family of either a sophisticated type (the standard rational type) or a mortal (behavioral) type, where mortal types are 'truth tellers' and 'liars' for senders, and 'believers' and 'inverters' (of the actions implicitly suggested by senders' messages) for receivers. Another related work is by Ottaviani and Squintani (2002), who study the information transmission in sender-receiver games under the possibility that the sender or the receiver is non-strategic. Their findings establish that the presence of behavioral types in

sender-receiver games involving a mix of behavioral and nonbehavioral types can be potentially found in currency exchange markets of emerging economies with current account problems. The objectives of a central bank (the sender) in such an economy may involve to strongly intervene in the forex market if the publicly known probability of the outflow of hot money is sufficiently high and to weakly intervene, only to dampen the volatility of exchange rates, otherwise. In the first situation, the central bank may choose to act nonstrategically while in the second situation it may strategically transmit information to the public or investors (the receiver) to ensure that exchange rates move in the opposite direction of the public's expectations.

Obviously, in sender-receiver games the awareness of intervention (or the presence of behavioral, in addition to conventionally studied strategic, type of senders) can induce an increased level of trust among those who are on the receiving side. At the same time, strategic senders can exploit this regulated situation if they adjust their actions based on the updated trust levels. So these opposing effects make the overall effect of intervention unclear. When a regulatory authority occasionally intervenes forcing the submitted messages to be truthful (or when some of the senders behave nonstrategically), how are the overall frequencies of truth-telling and trust affected? Motivated with this question, in this paper we study experimentally the behavior of subjects in a sender-receiver game under regulatory intervention and under no intervention. As usual, we will consider two games corresponding to these two situations.

Our Benchmark Game is identical to the sender-receiver games in Sánches-Pagés and Vorsatz (2007, 2009) and Peeters et al. (2008). In particular, the sender observes Nature's realization of a payoff table that could be of two equally likely types, over which the sender and the receiver have opposing interests. Each table involves two outcomes corresponding to two actions of a receiver. After Nature's choice of a table type, the sender submits a message, consisting of the type of the actual payoff table, to the receiver who is entirely uninformed about

the model leads to inflation in the equilibrium communication in contrast to the predictions of conventional models with nonbehavioral types.

Nature's choice. Because of this informational asymmetry, the sender can choose to lie whenever she finds it optimal. After observing the message of the sender, the receiver takes an action by trusting or distrusting the sender, and consequently the payoffs of the two players are determined by the actual state chosen by Nature and the action taken by the receiver.

In the alternative environment, namely the Regulated Game, the sequence of actions are the same as in the Benchmark Game, yet there is now a regulator which truthfully submits to the receiver Nature's choice of payoff table with commonly known probability $\alpha \in (0, 1/2)$.[3] Thus, a message about Nature's choice can be submitted by a strategic sender only with probability $1 - \alpha \in (1/2, 1)$.

Behavior predicted in all sequential equilibria of both the Benchmark and the Regulated Game implies that receivers never receive any relevant information. In the Benchmark Game the sender, who is always strategic, achieves this by submitting an untruthful message with probability one-half (due to the symmetric construction of the constant-sum payoff tables with respect to players and actions). In the Regulated Game, a strategic sender can submit message only with probability $1 - \alpha$; therefore, she can achieve the non-informativeness of the message that the receiver will observe, by lying with probability $0.5/(1-\alpha)$ whenever she is to submit any message. The receiver, anticipating that any communication he receives is only cheap-talk, chooses in both games each of his two actions with probability one-half so as to maximize his expected payoffs given the prior probabilities on the states chosen by Nature.[4]

We conduct our experiments in the Regulated Game when senders are behavioral with probability 0.3. The sequential equilibrium predicts both truthtelling and trust with probability one-half for the Benchmark Game (Corollary

[3]We are not interested in the case where $\alpha \in [1/2, 1]$, since if $\alpha = 1/2$ a strategic sender can use cheap talk only by lying with certainty and if $\alpha > 1/2$ the receiver would no longer find it optimal to ignore any message he receives.

[4]The sequential equilibrium in the Regulated Game, which we directly prove in Appendix A, can also be obtained as a corollary to Proposition 2 in Landi and Colucci (2008).

1 to Proposition 1) whereas truth-telling of strategic senders with probability 2/7 (28.6%) and trust with probability 1/2 for the Regulated Game (Corollaries 2 and 3 to Proposition 2). However, our results show that in the Benchmark Game senders tell the truth around 56% of the time while receivers trust 53% of the time. The observed excessive truth-telling and excessive trust are much higher for the Regulated Game. We find the frequency of truth-telling of strategic senders as high as 42% (in contrast to the prediction of 28.6%). Given the prior likelihood of strategic senders, the frequency of truthful messages the receivers get in the Regulated Game is as high as around 60%, clearly a case against the theoretical prediction of no information transmission by the two types of senders on average. This is, even more strikingly, despite the excessively high frequency of trust which we find around 61%.

Our final analysis deals with the question why we observe an increase in excessive truth-telling and excessive trust in the presence of a truthful regulator (a behavioral sender). In an attempt to give a partial answer, we examine the dynamic effects of the intervention of a truthful regulator in early periods of the experiments which are repeated for 50 period on the future levels of truth-telling and trust. Our regressions show that the more subjects benefit from telling the truth in the earlier periods of the Regulated Game, the more likely they will send correct messages in the further periods, while telling a lie or the truth in the future is found to be entirely random in the Benchmark Game. On the receiver side, we find that both the number of profitable experiences of trust and the number of observations of trust experienced by other players in the earlier periods increase the probability of the receiver's trusting other players later in the Regulated Game while the first one of these variables has the opposite effect in the Benchmark Game and the second one has no significant effect.

The paper is organized as follows: In Section 2, we introduce the model and theoretical predictions, and in Section 3 we present the experimental design. Afterwards, we report our experimental results, and finally, we conclude in Section 5. (Proofs and the instructions corresponding to the experimental games are in the Appendix.)

2 Model and Theoretical Predictions

In this section, we introduce the Benchmark and the Regulated Game; and then present the theoretical predictions. The Benchmark Game is a standard sender-receiver game (also studied by Sánches-Pagés and Vorsatz, 2007, 2009; and Peeters et al., 2008) with conflicting-interests, in which the sender privately learns the actual payoff table picked by Nature and is able to reveal this information to the receiver truthfully or not. Then the receiver, without learning the actual payoff table, takes an action that determines the payoffs for each player given the actual table that was chosen by Nature. In the Regulated Game, on the other hand, with some probability, the strategic sender is not allowed to take any action while the regulator (the behavioral sender) intervenes and reveals her private information truthfully to the receiver. The receiver, without knowing if the sender is restricted to tell the truth or not, takes an action given the information communicated by the sender, which determines the final payoffs (in the actual payoff table) for both players.

Below, we formally present these two games with their equilibrium predictions.

2.1 Benchmark Game

We denote the sender and the receiver by S and R, respectively. At the beginning of the game, Nature chooses a payoff table A or B with equal probability, i.e. $p(A) = p(B) = 1/2$, which determines the final payoffs of the players. The sender is privately informed about the realized payoff table. After the sender learns the actual payoff table, she sends a message σ_S (possibly a mixed strategy) from the set of possible messages $M = \{A, B\}$. For instance, $\sigma_S(A \mid B)$ denotes the probability of sending message A after learning that the actual payoff table is B. The receiver's strategy is choosing a (possibly mixed) action σ_R from the set of actions $\{U, D\}$ after observing the message submitted by the sender; for example $\sigma_R(U \mid A)$ denotes the probability that action U is chosen after observing that the sender communicated message A.

The payoff tables which are determined by Nature are as follows:

Table 1. Payoff tables

Table A	Sender	Receiver
Action U	x	1
Action D	1	x

Table B	Sender	Receiver
Action U	1	x
Action D	x	1

where $x > 1$. The game tree that describes the Benchmark Game is given by the following figure.

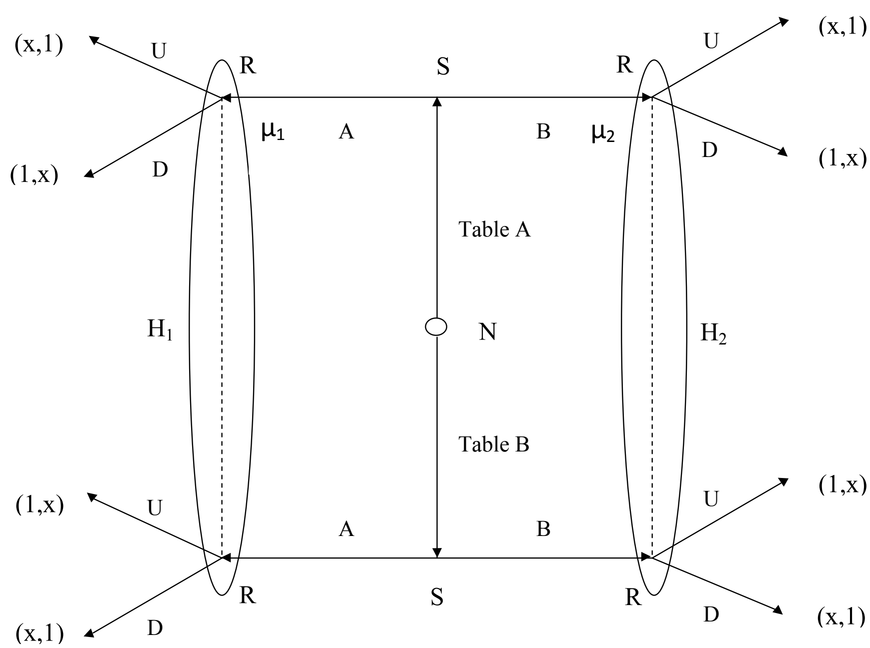

Figure 1: The Benchmark Game

Next we find the sequential equilibria of this game. Let $\mu_1 = p(A \mid A)$ (a belief at information set H_1 in Figure 1) denote the probability that Nature chose table A given that the receiver has observed message A; and similarly let $\mu_2 = p(A \mid B)$ (a belief at information set H_2 in Figure 1) denote the probability that Nature chose table A given that the receiver has observed message B.

Proposition 1 *The set of sequential equilibria of the Benchmark Game is the set of strategies* $(\sigma_S(A \mid A), \sigma_S(A \mid B); \sigma_R(U \mid A), \sigma_R(U \mid B)) = (p, p; q, q)$*, where* $p, q \in [0, 1]$ *and the supporting belief system* $(\mu_1, \mu_2) = (\frac{1}{2}, \frac{1}{2})$.

The proof of Proposition 1 can be found in Sánchez-Pagés and Vorsatz (2007). Besides, our next proposition that will characterize the sequential equilibrium in the Regulated Game will admit the above proposition as a special case. Proposition 1 states that in equilibrium the sender does not reveal any information and the receiver takes an action ignoring the messages submitted by the sender.[5] From the same proposition, we should also notice that:

Corollary 1 *In the Benchmark Game, the probability of sending an untruthful message by the sender is* $1/2$*. Similarly, the probability of expecting an untruthful message by the receiver is* $1/2$.

Proof. Omitted as it is straightforward. □

2.2 Regulated Game

In the Regulated Game, with some known probability $\alpha \in (0, 1)$, the strategic sender is not allowed to send any message. The game tree is illustrated in Figure 2. Here, $\mu_1 = p(\text{actual table is } A \text{ and sender is strategic} \mid \text{receiver observed message } A)$ is a belief at information set H_1 and $\mu_2 = p(\text{actual table is } A \text{ and sender is strategic} \mid \text{receiver observed message } B)$ is a belief at information set H_2. In this second game, the receiver, while calculating his beliefs, also takes into account the possibility that the sender is restricted to tell the truth.

[5] Although there are many sequential equilibria in the characterization of Proposition 1, one can assume that experimental subjects select some equilibria more often than the others. Sánchez-Pagés and Vorsatz (2007) present the Agent Quantal Response Equilibrium (AQRE) of McKelvey and Palfrey (1995, 1998) and find the unique logit-AQRE of the Benchmark Game, which is given by $(\sigma_S(A \mid A), \sigma_S(A \mid B); \sigma_R(U \mid A), \sigma_R(U \mid B)) = (\frac{1}{2}, \frac{1}{2}; \frac{1}{2}, \frac{1}{2})$, with the belief system $(\mu_1, \mu_2) = (\frac{1}{2}, \frac{1}{2})$.

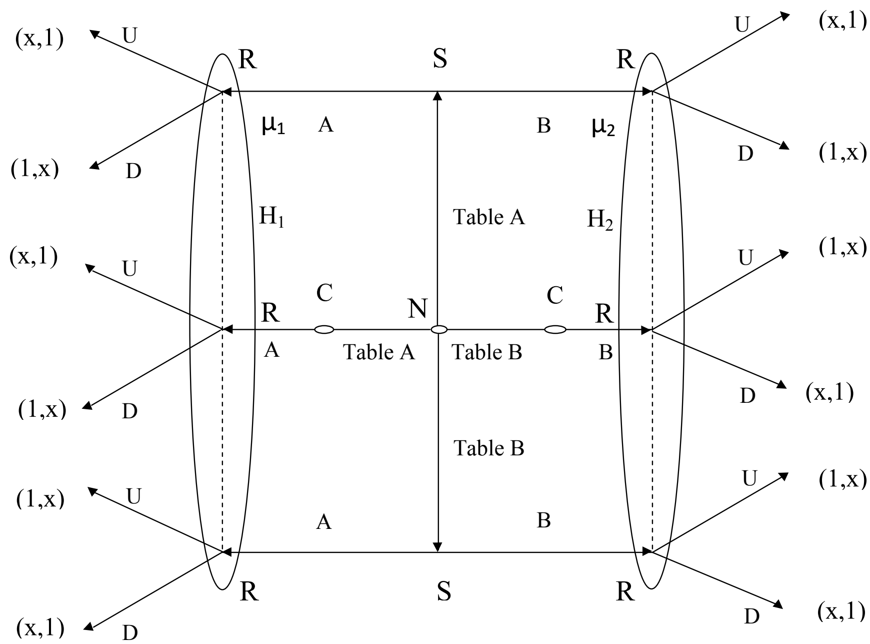

Figure 2: The Regulated Game

Proposition 2 *In any sequential equilibrium of the Regulated Game, the strategies satisfy*

$$\sigma_R(U \mid A) = \sigma_R(U \mid B) = p \in [0,1];$$

$$\sigma_S(B \mid A) - \sigma_S(B \mid B) = \frac{\alpha}{1-\alpha} \quad \textit{and} \quad \sigma_S(A \mid B) - \sigma_S(A \mid A) = \frac{\alpha}{1-\alpha};$$

with the supporting belief system $\mu_1 = \frac{1}{2} - k_1$*, where*

$$\begin{aligned} k_1 &= p(\textit{actual table is A and sender is behavioral} \mid \textit{receiver observed message A}) \\ &= \frac{\alpha}{\alpha + (1-\alpha)[\sigma_S(A \mid A) + \sigma_S(A \mid B)]}. \end{aligned}$$

Proof. See Appendix A. □

We notice that the above proposition admits Proposition 1 as a direct corollary, since the Regulated Game boils down to the Benchmark Game when $\alpha = 0$. Given Proposition 2, we can now derive the equilibrium level of truth-telling.

Corollary 2 *The probability of sending an untruthful message by the strategic sender is* $0.5/(1-\alpha)$.

Proof. The probability of sending an untruthful message is $(0.5)[\sigma_S(B \mid A) + \sigma_S(A \mid B)] = (0.5)[\sigma_S(B \mid A) + 1 - \sigma_S(B \mid B)] = 0.5/(1-\alpha)$. □

We would like to point out that as α approaches $1/2$, i.e., non-strategic and strategic information transmissions become equally likely, the probability of lying of the strategic sender approaches 'one'. Now, we calculate the total probability of receiving untruthful messages.

Corollary 3 *The total probability of the receiver's observing an untruthful message is 0.5.*

Proof. We calculate the probability of seeing an untruthful message as

$$\begin{aligned}
&0.5(1-\alpha)[\sigma_S(B \mid A) + \sigma_S(A \mid B)] \\
&= 0.5(1-\alpha)[\sigma_S(B \mid A) + 1 - \sigma_S(B \mid B)] \\
&= 0.5(1-\alpha)[1 + \frac{\alpha}{1-\alpha}] = 0.5. \quad \square
\end{aligned}$$

The last corollary predicts the equilibrium behavior of the receiver to be the same in both games. Also, note that when $\alpha = 0$, we are back to the Benchmark Game, where the probability of truth-telling is one-half. As α increases, the probability of lying by the strategic sender rises (and approaches to 1 as α goes to $1/2$). For instance, for $\alpha = 1/3$, the probability of lying by the strategic sender is as high as $5/7$ (0.714). The strategic sender increases the amount of lying just to even out the expected excessive truth-telling by the behavioral sender so that the messages receivers get do not contain any relevant information.

The last point we would like to make is that the equilibrium behavior is independent of the value of x a long as $x > 1$, i.e., there is some degree of conflicting interest between the sender and the receiver.

3 Experimental Design and Procedures

We conducted all experimental sessions in the Social Sciences Laboratory at TOBB University of Economics and Technology during June 6-8, 2011. Students were invited by e-mail and they could register online for a session they prefer, subject to availability. We ran a total of 8 sessions (each with 12 subjects), four on the Benchmark and four on the Regulated Game. Each session involved 12 subjects, making a total of 96 subjects. We performed our experiments with the computer software z-Tree developed by Fischbacher (2007).

Our design is based on the setup used in Sánchez-Pagés and Vorsatz (2007, 2008) and Peeters et al. (2008). The Benchmark Game is based on a sender-receiver game where the interests of a sender and a receiver diverge in different states which are equally likely to occur. The sender, being informed about the true state, sends a signal to the receiver who is uninformed. The receiver then takes a payoff-relevant action. Different states are represented by different payoff tables in Table 1, which are named as "payoff table A" and "payoff table B". The variable x in payoff tables A and B in Table 1 was set to 9 for all sessions, while the monetary unit for all payoffs was Turkish Lira (TL). In both states, there are two available signals that the sender can choose among: "The payoff table is A" or "The payoff table is B". After observing the signal the receiver is asked which payoff table he thinks is more likely to be the correct one. The receiver then chooses among two possible actions: "U" or "D". After he chooses the action, the payoffs are realized accordingly and a summary of the period is shown to both of the parties. This summary includes information about the true state, the signal sent, the belief of the receiver, the action chosen by the receiver and the payoffs to both the sender and the receiver.

In the Benchmark Game, subjects in each session played the game described above for 50 periods. 12 subjects in each session were divided into two groups of 6. The formation of the groups was random, and the identities and the actions of group members remained anonymous. Every subject was matched only with subjects within the same group, and with each of them she or he played 5 times as a sender and 5 times as a receiver. Thus, a subject played 25 times in both roles while the order of the matchings and the role assignments were random.[6]

In the Regulated Game subjects played the same game in the same sequence, however, at each period there was a 30% chance that the computer would stop the strategic sender from choosing a message. In such periods of intervention, a correct signal was sent to the receiver while the strategic sender was told that she will not have a choice over the signal and the system would send the correct signal to the receiver. Regardless of the intervention, the receiver was given information about the signal in the same manner. Hence, he was uninformed about the source of the signal and whether an intervention occurred or not. There was no predetermined arrangement for the occurrences of intervention and these occurrences were independent across subjects and periods.

Payments were paid in private at the end of each session in each game. Each subject was paid twice the average of his or her earnings during 50 periods plus a participation fee of 5 TL. The average earnings of the subjects were 4.9938 TL (exactly 5 TL in the Benchmark Game and 4.9875 TL in the Regulated Game). At the time of the experiment, 1 TL corresponded to 0.6325 USD.

4 Results

We present in Figure 3 the histograms for truth-telling frequencies calculated by measuring the share of the correct signals of the senders among signals initiated by themselves. In the Benchmark Game, all signals are initiated by senders hence each sender has 25 (out of 50) chances to lie. But, in the Regulated Game, a strategic sender could initiate the signals only when the computer did not

[6]This matching protocol generates 1200 sender decisions and 1200 receiver decisions for both games. Out of 4800 period observations in total, 6 are dropped due to errors in type assignment.

intervene. As can be seen from the left hand side histogram, majority of the strategic senders in the Benchmark Game sent correct messages in around 50-60% of all observations, the average frequency being 55.5%. Compared to them, conditional on no intervention, the strategic senders in the Regulated Game sent correct messages (as shown in the right hand side histogram in Figure 3) less often with the average frequency of truth-telling being 42% and one third of the population (16 out of 48) telling the truth 30% of the time or less often.

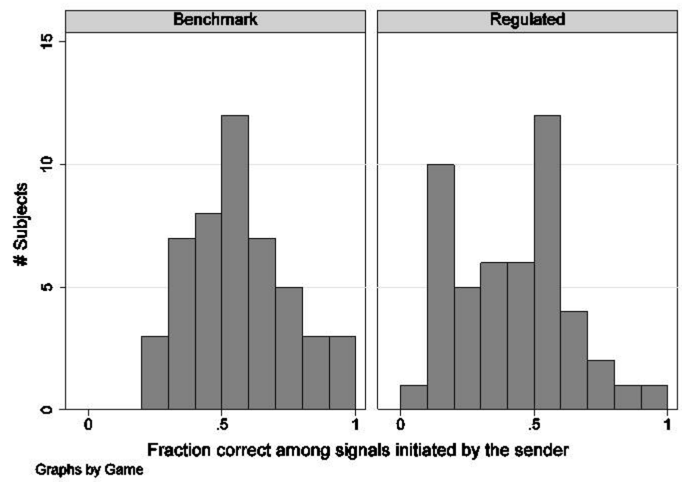

Figure 3: Allocation Choices in the Benchmark Game

In Figure 4, we present the evolution of correct messages both for the Benchmark and the Regulated Game. Note that overall truth-telling in the Regulated Game also includes the correct messages sent through computer intervention which makes the overall percentage of truth 59.7% . For both games, we observe that the overall percentage of correct messages seems to be oscillating around its mean.

The theoretical predictions presented in Section 2 imply that the senders will lie or tell the truth with equal frequencies (50%) in the Benchmark Game. As a result, the best reply for the receivers would be disregarding the signal and choosing randomly among actions U and D. For the Regulated Game, these predictions imply that in case of no intervention (which occurs with probability 0.7), the strategic senders will lie with probability 0.714 (5/7 is the exact value predicted). This would make the overall probability of an incorrect signal 0.5, leaving the receivers uninformed. Hence, the best replies for the receivers would be the same as in the Benchmark Game.

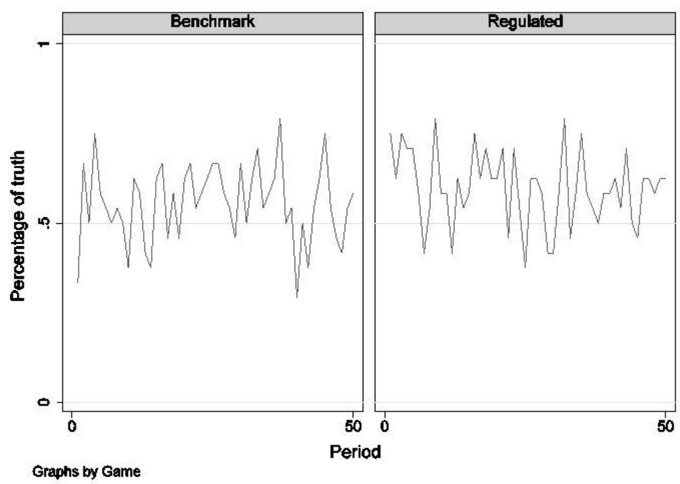

Figure 4: Evolution of the Overall Percentage of Correct Signals

The frequency with which correct signals were sent is found to be higher than the theoretical prediction for both games. This observation is consistent with most of the previous studies. The frequency of truth-telling in similar benchmark (baseline) games with the same equilibrium predictions was found to be 55.07% and 50.6% in Sánchez-Pagés and Vorsatz (2007) over the last forty rounds when $x = 2$ and $x = 9$ respectively; 53.4% in Peeters et al. (2008) when $x = 6$ but the lowest payoff was 2; 51.67% and 53.9% in Sánchez-Pagés and Vorsatz (2009) when $x = 5$ for two different cost specifications of the model respectively.

In the Benchmark Game, we observe a probability around 55.5% of a message being correct. On the other hand, for the Regulated Game, given the strategic sender behavior and the prior likelihood of an intervention, the posterior probability of a message being correct is around 59.7%. In Figure 5, we present the histograms for trust frequencies in the Benchmark and the Regulated Game, by measuring in each game the share of the signals trusted by the receivers among all signals received by them; and in Figure 6 we present the cyclical evolution of trust frequencies in the two games.[7] For the Benchmark Game, the distribution is relatively concentrated around 50% with the mean being 53.7%. For the Regulated Game the distribution is more scattered and the trust level is generally higher with the mean being 61.3%. This difference between the results in the two games is also statistically significant (p-value < 0.01 in a two sample Wilcoxon rank-sum test).

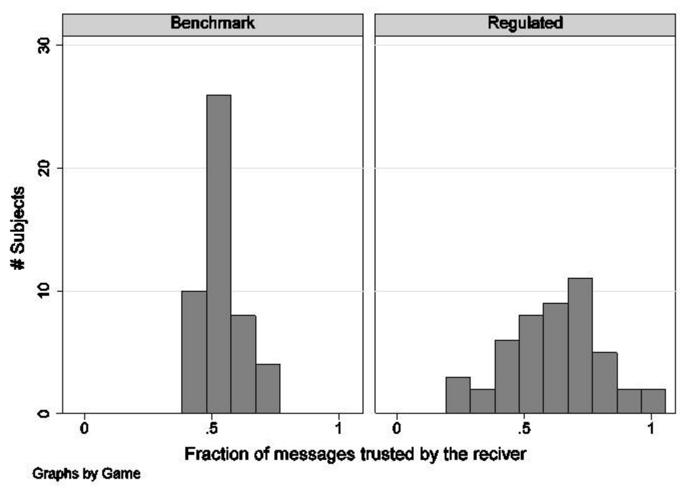

Figure 5: Allocation Choices in the Regulated Game

[7]The receiver is said to be trusting the sender (whether strategic or nonstrategic) if he takes the action that gives the highest payoff with respect to the table signalled by the sender.

The theoretical predictions imply that in both games a receiver will behave in the same way by treating messages as cheap talk and will choose actions U and D with equal frequencies. This implies an overall trust frequency of 50% for both games. For the Benchmark Game, the actual value of this frequency is slightly above the predicted value. For the Regulated Game, there is a larger difference between the actual and the predicted frequencies of trust. For both the Benchmark and the Regulated Game, these frequencies are significantly different from the predicted value of 50% (p-values less than 0.01 in one sample test of proportions for both games).

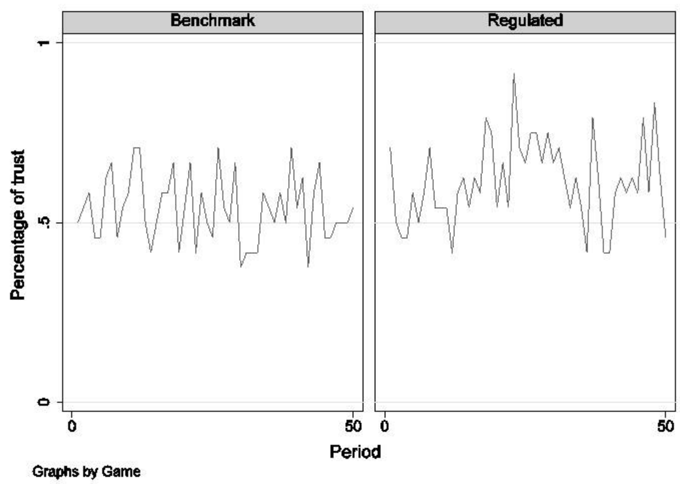

Figure 6: Evolution of the Percentage of Signals Trusted by the Receivers

For the Benchmark Game, the overall behavior can be summarized as the senders behaving slightly more truthful and the receivers trusting slightly more often than predicted by the theory. For the Regulated Game, the absolute differences between the predicted and actual frequencies of truth-telling and trust are much higher. The overall behavior in this game can be summarized as the senders not fully exploiting the intervention system and the receivers trusting much more often than the predicted values.

When the first 10 periods in which the subjects may be assumed to be learning the rules of the games are excluded, the overall frequency of correct messages (including both deliberate truth-telling and computer intervention) is found to be around %58.5 over the last 40 periods. This value is slightly above the frequency observed in the Benchmark Game (56.1%) for the same time span, however the difference is not significant (p-value = 0.288 in a Wilcoxon rank-sum test). Even though the frequency of correct messages received is very similar in both games, the frequency of trust over the last 40 periods is much higher for the Regulated Game than for the Benchmark Game (62.7% versus 53.6%, p-value less than 0.01 in a Wilcoxon rank-sum test). To summarize, during the last 40 periods, both games induce similar frequencies of correct signals which is above 50%, but the overall trust level is much higher in the Regulated Game.

We also focus on the effect of experience in earlier periods on the likelihood of truth-telling and trust on later periods. In the case of truth-telling we look at the effects of profitable truth-telling experiences a subject accumulates in the role of a sender and truth-telling frequencies of other senders with whom the same subject interacts in the role of a receiver on the subject's truth-telling tendency in later periods. Similarly, in the case of trust, we look at the effects of profitable trust experiences and the observed trust frequencies of other subjects on a subject's likelihood of trusting senders' messages in later periods.

To this end, we conduct several logistic regression results of which are summarized in Tables 2 and 3. Below we explain these results in more detail.

Table 2: In constructing our variables, we divide each game in two halves. The dependent variable is *correct signal* which is equal to 1 if a subject (as a sender) told the truth and 0 otherwise, and this variable only includes observations from the second half of the game. Our independent variables are *profitable truth-telling experience*, *observed truth-telling*, *profitable truth-telling experience - normalized* and *observed truth-telling - normalized*. The first one of these counts the number of periods during the first half that the subject lied in the role of

Table 2: Effect of Experience on Truth-Telling[a]

Dependent Variable: Correct Signal

	Benchmark		Regulated	
Profitable truth-telling experience	0.025		0.106***	
	(0.016)		(0.030)	
Profitable truth-telling experience - normalized		0.368*		0.696***
		(0.212)		(0.208)
Observed truth-telling	-0.003		0.021	
	(0.020)		(0.017)	
Observed truth-telling - normalized		-0.053		-0.026
		(0.264)		(0.269)
Male	0.083	0.078	-0.094	-0.097
	(0.075)	(0.075)	(0.079)	0.079
N	600	600	425	425
Prob > chi2	0.193	0.164	0.002	0.005
Pseudo R^2	0.014	0.015	0.043	0.033

[a]The table reports the marginal effects of the different variables on telling a lie and the clustered robust standard errors are given in parenthesis. ***, **, * denote 1, 5, and 10% confidence levels, respectively.

a sender and earned 9 TL, the highest payoff in the two games.[8] The second one counts the number of periods during the first half of the game that the subject saw a correct message in the role of a receiver. Since the role assignment was not balanced for subjects during the first and the second half of each game,

[8]Note that in the Regulated Game, we excluded the periods where the signal was sent by the computer.

Table 3: Effect of Experience on Trusting[a]

Dependent Variable: Trust

	Benchmark		Regulated	
Profitable trust experience	-0.028^{**}		0.057^{***}	
	(0.011)		(0.016)	
Profitable trust experience - normalized		-0.324^{**}		0.685^{***}
		(0.134)		(0.219)
Observed trust	0.002		0.036^{**}	
	(0.008)		(0.014)	
Observed trust - normalized		0.048		0.094
		(0.137)		(0.116)
Male	0.035	0.034	0.188^{***}	0.166^{***}
	(0.046)	(0.045)	(0.057)	0.061
N	600	600	600	600
Prob > chi2	0.071	0.034	0.000	0.000
Pseudo R^2	0.009	0.045	0.074	0.069

[a]The table reports the marginal effects of the different variables on telling a lie and the clustered robust standard errors are given in parenthesis. ***, **, * denote 1, 5, and 10% confidence levels, respectively.

we need normalized measures to account for subject experience. Consequently, we constructed *profitable truth-telling experience - normalized* which is *profitable truth-telling experience* divided by "total chances to lie in the first half of the game", and *observed truth-telling - normalized* which is *observed truth-telling* divided by "the number of times the subject was a receiver in the first half of the game". We also control for the gender of the subjects. Regardless of the variable we use for measuring profitable truth-telling experience, we see that the more subjects benefit from telling the truth, the more likely they will send correct signals in the further periods during the Regulated Game with the effects being significant at 1% level. This effect does not exist in the Benchmark Game where the experience in the first half of the game does not seem to affect the propensity of truth-telling in the second half. It appears that telling a lie or telling the truth remains as a random choice throughout the Benchmark Game rather than a strategy shaped (to some extent) by previous experience.

Table 3: The dependent variable here is *trust* which is equal to 1 if a subject (as a receiver) trusted the receiver's message and 0 otherwise, and it includes observations from the second half of the game, only. The independent variables we use here are *profitable trust experience*, *observed trust*, *profitable trust experience - normalized* and *observed trust - normalized*. The first one of these is equal to the number of times in the first half of the game that the subject played as a receiver, trusted the sender's message and obtained a high payoff. The second one counts the number of times in the first half of the game that the subject played as a sender and her message was trusted by the receiver. The variable *profitable trust experience - normalized* is *profitable trust experience* divided by "number of times the subject was a receiver in the first half of the game" and *observed trust - normalized* is *observed trust* divided by "total chances to lie in the first half of the game". Controlling for the gender effects, we find that profitable experiences of trust in early periods and observing trust among others increases the likelihood of trusting others later in the Regulated Game while only profitable experiences of trust has a significant (but opposite) effect for the Benchmark Game. Interestingly, the receivers in our Benchmark Game seem to have always made correct dynamic calculations so that the end-of-the-game average of their trust experience was around the theoretical prediction of trusting the sender, on the average, once in every two plays, irrespective from the trust experiences and observations they had accumulated in the earlier parts of the game.

5 Concluding Remarks

A growing literature on experimental economics has established overcommunication in strategic transmission games involving fully strategic agents with conflictive preferences. In those games, the sender of a strategic information is observed to tell the truth more often than predicted by the theoretical model of Crawford and Sobel (1982). In this paper, we have studied whether this phenomenon is stable with respect to the random intervention of an honest regulator in the transmission game. To this end, we designed a Regulated Game, in addition to our Benchmark Game which we borrowed from the earlier literature. This new game allowed a truthful regulator to submit the private information of a strategic sender with a commonly known probability.

While the sequential equilibria of both the Benchmark Game and the Regulated Game predict no information transmission, our results showed that a strategic sender exhibited excessive truth-telling in both games. More interestingly, the size of excessive truth-telling by strategic senders was much higher in the presence of random intervention. Besides, the average communication level by the strategic and non-strategic senders was also excessively high. These findings clearly show that the recent literature experimentally invalidating the theoretical predictions is robust with respect to the inclusion of a behavioral sender type in the information transmission game.

On the receiver end of our information transmission games, we observed excessive trust behavior. More interestingly, the receivers seem to have correctly perceived in the Regulated Game the overcomunication of strategic senders. Indeed, we found that the average trust level of receivers was 22% higher than foreseen by the sequential equilibrium while the strategic senders' excessive truth-telling exceeded the theoretically predicted level by 20%. From the perspective of economic policy, our results may suggest that in principal-agent settings intervention pays to a honest regulator acting on behalf of the informationally inferior agents.

Finally, we analysed the dynamic roots of excessive truth-telling and trust in the two strategic games. Our regressions showed that under intervention the more a strategic sender found truth-telling profitable in the earlier rounds of experiments, the more likely she told the truth in the subsequent rounds. In the Benchmark Game, however, the past experience of strategic senders did not have a predictive power to explain their overcommunication in the future. We also showed that profitable experiences of trust in early periods as well as observing trust among other players increase the likelihood of trust later in the Regulated Game, while we found an opposite effect of profitable experiences of trust for the Benchmark Game.

Appendix A. Proof of Proposition 2

We will first find the best response correspondences of the receiver and the strategic sender. At information set H_1 in Figure 2, the receiver observes that the message that has been sent is A, which might have come from a strategic sender who could reveal his information truthfully or untruthfully, or from a behavioral sender who observed the actual table is A and had been restricted to send a truthful message. Let the beliefs at information set H_1 be defined as:

$$\begin{aligned} \mu_1 &= p(\text{actual table is } A \text{ and sender is strategic} \mid \text{receiver observed message } A) \\ k_1 &= p(\text{actual table is } A \text{ and sender is behavioral} \mid \text{receiver observed message } A) \end{aligned}$$

Then, the receiver's expected payoff by choosing U is:

$$\mu_1 + k_1 + (1 - k_1 - \mu_1)x$$

On the other hand, if the receiver plays D, his expected payoff is:

$$\mu_1 x + k_1 x + (1 - k_1 - \mu_1)$$

So, the best response correspondence of the receiver at information set H_1 is given by:

$$\sigma_R(U \mid A) \in \begin{cases} \{1\} & \text{if} \quad \mu_1 \leq \frac{1}{2} - k_1 \\ [0,1] & \text{if} \quad \mu_1 = \frac{1}{2} - k_1 \\ \{0\} & \text{if} \quad \mu_1 \geq \frac{1}{2} - k_1 \end{cases}$$

At information set H_2, we define the beliefs of the receiver as:

$$\mu_2 = p(\text{actual table is } A \text{ and sender is strategic} \mid \text{receiver observed message } B)$$
$$k_2 = p(\text{actual table is } A \text{ and sender is behavioral} \mid \text{receiver observed message } B)$$

Thus, the receiver's expected payoffs from playing U and D, are as follows. If the receiver plays U, his expected payoff is:

$$\mu_2 + k_2 x + (1 - k_2 - \mu_2)x$$

If the receiver plays D, his expected payoff is:

$$\mu_2 x + k_2 + (1 - k_2 - \mu_2)$$

Then, the best response correspondence of the receiver at information set H_2 is given by:

$$\sigma_R(U \mid B) \in \begin{cases} \{1\} & \text{if} \quad \mu_2 \leq \frac{1}{2} \\ [0,1] & \text{if} \quad \mu_2 = \frac{1}{2} \\ \{0\} & \text{if} \quad \mu_2 \geq \frac{1}{2} \end{cases}$$

Now we find the best response correspondence of the strategic sender who knows that the actual payoff table is A. The expected payoff from sending the message A (telling the truth) is:

$$\sigma_R(U \mid A)x + [1 - \sigma_R(U \mid A)]$$

The expected payoff from sending the message B (revealing the information untruthfully) is:

$$\sigma_R(U \mid B)x + [1 - \sigma_R(U \mid B)]$$

Thus, the best response correspondence of the sender who knows that the actual payoff table is A becomes:

$$\sigma_S(A \mid A) \in \begin{cases} \{1\} & \text{if} \quad \sigma_R(U \mid A) \geq \sigma_R(U \mid B) \\ [0,1] & \text{if} \quad \sigma_R(U \mid A) = \sigma_R(U \mid B) \\ \{0\} & \text{if} \quad \sigma_R(U \mid A) \leq \sigma_R(U \mid B) \end{cases}$$

Similarly, we can find the best response correspondence of the strategic sender who knows that the actual payoff table is B. The expected payoff from sending the message A is

$$\sigma_R(U \mid A) + [1 - \sigma_R(U \mid A)]x,$$

whereas the expected payoff from sending the message B is

$$\sigma_R(U \mid B) + [1 - \sigma_R(U \mid B)]x.$$

So, the best response correspondence of the sender who knows that the actual payoff table is B becomes:

$$\sigma_S(A \mid B) \in \begin{cases} \{1\} & \text{if} \quad \sigma_R(U \mid A) \leq \sigma_R(U \mid B) \\ [0,1] & \text{if} \quad \sigma_R(U \mid A) = \sigma_R(U \mid B) \\ \{0\} & \text{if} \quad \sigma_R(U \mid A) \geq \sigma_R(U \mid B) \end{cases}$$

The beliefs μ_1 (that Nature chose table A and the sender was strategic given that the receiver has observed message A) and k_1 (that Nature chose table A and the sender was behavioral given that the receiver has observed message A) are calculated as follows:

$$\begin{aligned} \mu_1 &= \frac{\sigma_S(A \mid A)(1-\alpha)\frac{1}{2}}{\sigma_S(A \mid A)(1-\alpha)\frac{1}{2} + \frac{\alpha}{2} + \sigma_S(A \mid B)(1-\alpha)\frac{1}{2}} \\ &= \frac{\sigma_S(A \mid A)(1-\alpha)}{[\sigma_S(A \mid A) + \sigma_S(A \mid B)](1-\alpha) + \alpha} \\ k_1 &= \frac{\alpha}{\alpha + (1-\alpha)[\sigma_S(A \mid A) + \sigma_S(A \mid B)]} \end{aligned}$$

Similarly, the beliefs μ_2 (that Nature chose table A and the sender was strategic given that the receiver has observed message B) and k_2 (that Nature chose table A and the sender was behavioral given that the receiver has observed message

B) are given by:

$$\mu_2 = \frac{\sigma_S(B \mid A)(1-\alpha)\frac{1}{2}}{\sigma_S(B \mid A)(1-\alpha)\frac{1}{2} + \frac{\alpha}{2} + \sigma_S(B \mid B)(1-\alpha)\frac{1}{2}}$$

$$= \frac{\sigma_S(B \mid A)(1-\alpha)}{[\sigma_S(B \mid A) + \sigma_S(B \mid B)](1-\alpha) + \alpha}$$

$$k_2 = \frac{\alpha}{\alpha + (1-\alpha)[\sigma_S(B \mid A) + \sigma_S(B \mid B)]}$$

To complete the proof, we make the following three claims.

Claim 1. $\mu_1 = \frac{1}{2} - k_1$ and $\mu_2 = \frac{1}{2}$ in any equilibrium.

Proof of Claim 1. Suppose for a contradiction that $\mu_1 > \frac{1}{2} - k_1$. Then, by substituting $1 - \sigma_S(B \mid A) \equiv \sigma_S(A \mid A)$ and $1 - \sigma_S(B \mid B) \equiv \sigma_S(A \mid B)$ in the definition of μ_1, we get that $\mu_2 < \frac{1}{2}$. With these beliefs ($\mu_1 > \frac{1}{2} - k_1$ and $\mu_2 < \frac{1}{2}$), the best reply of the receiver is $\sigma_R(U \mid A) = 0$ after observing the message A and $\sigma_R(U \mid B) = 1$ after observing the message B. In turn, the best reply of the strategic sender is $\sigma_S(A \mid A) = 0$ after learning that the actual payoff table is A and $\sigma_S(A \mid B) = 1$ after learning that the actual payoff table is B. Given the strategies of the sender, we calculate $\mu_1 = 0$, which contradicts with $\mu_1 > \frac{1}{2} - k_1$.

Now, suppose that $\mu_1 < \frac{1}{2} - k_1$. Then, by substituting $1 - \sigma_S(B \mid A) \equiv \sigma_S(A \mid A)$ and $1 - \sigma_S(B \mid B) \equiv \sigma_S(A \mid B)$ in the definition of μ_1, we get that $\mu_2 > \frac{1}{2}$. With these beliefs ($\mu_1 < \frac{1}{2} - k_1$ and $\mu_2 > \frac{1}{2}$), the best reply of the receiver is $\sigma_R(U \mid A) = 1$ after observing the message A and $\sigma_R(U \mid B) = 0$ after observing the message B. In turn, the best reply of the strategic sender is $\sigma_S(A \mid A) = 1$ after learning that the actual payoff table is A and $\sigma_S(A \mid B) = 0$ after learning that the actual payoff table is B. Given the strategies of the sender, we calculate $\mu_2 = 0$, a contradiction.

Therefore, the only possibility is $\mu_1 = \frac{1}{2} - k_1$, which necessitates $\mu_2 = \frac{1}{2}$.

Claim 2. $\sigma_R(U \mid A) = \sigma_R(U \mid B) = p \in [0, 1]$.

Proof of Claim 2. Suppose not. Then either $\sigma_R(U \mid A) > \sigma_R(U \mid B)$ or vice versa. If $\sigma_R(U \mid A) > \sigma_R(U \mid B)$, then the best response of the sender is $\sigma_S(A \mid A) = 1$ after learning that the payoff table is A and $\sigma_S(A \mid B) = 0$ after learning that the payoff table B, which results in $\mu_2 = 0$, which is a contradiction by Claim 1. If, on the other hand, $\sigma_R(U \mid A) < \sigma_R(U \mid B)$, we arrive to the contradiction that $\mu_1 = 0$. Thus, $\sigma_R(U \mid A) = \sigma_R(U \mid B) = p \in [0, 1]$.

Given that $\sigma_R(U \mid A) = \sigma_R(U \mid B) = p \in [0, 1]$, the best reply of the sender dictates that $\sigma_S(A \mid B)$ and $\sigma_S(A \mid A)$ can be any mixed strategy.

Claim 3. In any sequential equilibrium of the Regulated Game, the strategic sender's strategies satisfy

$$\sigma_S(B \mid A) - \sigma_S(B \mid B) = \frac{\alpha}{1-\alpha} \quad \text{and} \quad \sigma_S(A \mid B) - \sigma_S(A \mid A) = \frac{\alpha}{1-\alpha}.$$

Proof of Claim 3. For consistency of beliefs, the only possibility is $\mu_1 = 0.5 - k_1$, which necessitates $\mu_2 = 0.5$. Note that given that $\mu_2 = 0.5$, $\sigma_S(B \mid A) - \sigma_S(B \mid B) = \alpha/(1-\alpha)$, which also implies $\sigma_S(A \mid B) - \sigma_S(A \mid A) = \alpha/(1-\alpha)$.

This completes the proof of Proposition 2. □

Appendix B. Instructions (Regulated Game)[9]

Welcome!

Thank you for your participation. The aim of this study is to understand how people decide in certain situations.

From now on, talking to each other is prohibited. If you have a question please raise your hand. This way, everyone will hear the question and the answer.

The experiment will be conducted on the computer and you will make all your decisions there. You will earn a reward in the game that will be played during the experiment. This

[9] Instructions for the Benchmark Game have minor differences and do not include the parts describing computer system intervention to the message. We did not include the pictures referred in the text here since the experimental software is built on Sánches-Pagés and Vorsatz (2007) which already includes the screenshots of the software.

reward will depend on your decisions as well the decisions of other participants. The reward and the participation fee will be paid in cash at the end of the experiment.

We start with the instructions.

In this experiment, you will play a game that will last for 50 rounds. Before the first round, the system will divide the participants to two groups of 6 people. These groups will stay the same throughout the experiment. A participant in a given group will only play with participants from that group, but will not learn the identities of other participants in the group.

Let us now describe the game on more detail. Please do not hesitate to ask questions.

At the beginning of each round, you will match with another participant from your group. In this matching, one participant will be determined as 'sender' and the other participant will be determined as 'receiver'. All of you will play 25 times as a sender and 25 times as a receiver. At the end of the game all group members will have been matched with each other equal number of times. So, you will play 5 times as a sender and 5 times as a receiver with each member in the group. The order of matchings and role assignments are randomly determined.

At each round, after the matchings and the role assignments are completed, the system will choose one among the A and B tables below. Each table is equally likely to be chosen by the system. The earnings in that round will depend on the table chosen by the system and the action chosen by the receiver.

Table A	Sender	Receiver
Action U	9	1
Action D	1	9

Table B	Sender	Receiver
Action U	1	9
Action D	9	1

Sender's task:

At the beginning of each round, the sender will be informed about the table chosen by the system in that round. the sender is the first to make a decision in the game. She will tell the receiver which payoff table is chosen by the system (see picture 1). She is free to send correct or wrong message.

But, at some rounds, system will not allow the sender from sending a message and the receiver will be told the correct table chosen by the system. The probability of this happening is 30%. During such rounds, the sender will observe that the system is sending the message on behalf of her but will not be able to make a choice (see picture 2).

The receiver will not learn, during any of the rounds, whether the message is sent by the sender or the system.

Receiver's task:

The receiver will first see the message sent to him (picture 3). On the screen that he observes this message, the receiver will also be asked which table he believes is more likely to determine the earnings in that round.

On the next screen, the receiver will choose one among the actions U and D. (picture 4). On this screen, at the top, he can see how earnings are determined in tables A and B. At the bottom of this, he can see the message he received and the belief he stated on the previous screen.

After the receiver makes his choice, the earnings will be determined by the actual table chosen by the system and the choice of the receiver.

At the end of each round, on the summary screen (picture 5 for the receiver and picture 6 for the sender) players can see

- the table chosen by the system,
- the message received by the receiver,
- the action chosen by the receiver,
- the sender's earnings,
- the receiver's earnings.

Payments:

Based on your earnings in each round, we will calculate your average earning. You can see this on the summary table located at the bottom of the screen. We will pay you twice the average of your earnings. In addition to this, you will receive a participation fee of 5 TL. Nobody else, other than yourself, will be allowed to observe your earnings. You can leave the room after you receive your payment.

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References

[1] Blanes i Vidal, J., (2003). Credibility and cheap talk of securities analysts: theory and evidence, Job Market Paper, London School of Economics.

[2] Cai, H., Wang, J., (2006). Overcommunication in strategic information transmission games. *Games and Economic Behavior*, 56(1), 7-36.

[3] Costa-Gomes, M., Crawford, V., Broseta, B., (2001). Cognition and behavior in normal form games: en experimental study, *Econometrica*, 69, 1193-1235.

[4] Crawford, V., (2003). Lying for strategic advances: rational and boundedly rational misrepresentations of intentions, *American Economic Review*, 93, 133-149.

[5] Crawford, V., Sobel, J., (1982). Strategic information transmission, *Econometrica*, 50(6), 1431-1451.

[6] Dickhaut, J., McCabe, K., Mukherji, A., (1995). An experimental study of strategic information transmission, *Economic Theory*, 6, 389-403.

[7] Fischbacher, U., (2007). Z-Tree – Zurich toolbox for readymade economic experiments, *Experimental Economics*, 10, 171-178.

[8] Gilligan, T.W., Krehbiel, K., (1987). Collective decision making and standing committees: an informational rationale for restrictive amendment procedures, *Journal of Law, Economics, and Organization*, 3(2), 287-335.

[9] Gneezy, U., (2005). Deception: the role of consequences, *American Economic Review*, 95, 384-394.

[10] Kőszegi, B., (2006). Emotional agency, *Quarterly Journal of Economics*, 121(1), 121-156.

[11] Landi, M., and Colucci, D., (2008). Rational and boundedly rational behavior in sender-receiver games, Research Collection School of Economics, Paper 897.

[12] McKelvey, R., Palfrey, T., (1995). Quantal response equilibria in normal form games, *Games and Economic Behavior*, 10, 6-38.

[13] McKelvey, R., Palfrey, T., (1998). Quantal response equilibria in extensive form games, *Experimental Economics*, 1, 9-41.

[14] Nagel, R., (1995). Unravelling in guessing games: an experimental study, *American Economic Review*, 85, 1313-1326.

[15] Novshek, W., Sonneschein, H., (1982). Fulfilled expectations Cournot duopoly with information acquisition and release, *Bell Journal of Economics*, 13, 214-218.

[16] Ottaviani, M., Squintani, F., (2002). Non-fully strategic information transmission, Wallis Working Papers WP29, University of Rochester - Wallis Institute of Political Economy.

[17] Peeters, R., Vorsatz, M., Walz, M., (2008). Rewards in an experimental sender-receiver game, *Economics Letters*, 101(2), 148-150.

[18] Rosovsky, H., Hartley, M., (2002). Evaluation and the academy: are we doing the right thing? Grade inflation and letters of recommendation, Cambridge, MA: American Academy of Arts and Sciences.

[19] Sánchez-Pagés, S., Vorsatz, M., (2007). An experimental study of truth-telling in a sender receiver game, *Games and Economic Behavior*, 61, 86-112.

[20] Sánchez-Pagés, S., Vorsatz, M., (2009). Enjoy the silence: an experiment on truth-telling, *Experimental Economics*, 12, 220-241.

[21] Stahl, D.O., Wilson, P.W., (1994). Experimental evidence on players' models of other players, *Journal of Economic Behavior and Organization*, 25(3), 309-327

[22] Stahl, D.O., Wilson, P.W., (1995). On players' models of other players: theory and experimental evidence , *Games and Economic Behavior*, 10(1), 218-254