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Essays on Persuasion Games with Hard Evidence

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Summary*

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The thesis consists of three chapters. In the first chapter we study a communication game played by three agents with conflicting and state independent preferences. Each possible outcome of the game uniquely corresponds to a state of the world. The objective is to construct an outcome function (mechanism) that provides the agents with incentives to take actions so that the "true" outcome is implemented. Without any hard evidence in the model communication is worthless. However, if let the agents receive evidence to prove the state with infinitesimal probability we are able to induce truthful implementation in every equilibrium. The model resembles a situation of competition among advocates and our main result demonstrates wide possibilities (and economic intuition) for information aggregation within the adversarial procedure.

In the second chapter we consider a trial game between a defendant and a judge and focus on the effects of the defendant's right to remain silent. We provide a rationale for why there is no rule against adverse inference from silence in civil procedure.

The third chapter relates to corporate governance. We show that, at the initial selling of shares, a controlling founder may have adverse incentives in terms of signaling low expropriation of outside shareholders.

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Italian: La tesi si compone di tre capitoli. Nel primo capitolo studiamo un gioco di comunicazione interpretato da tre agenti in conflitto con il pay-off e lo stato indipendente. Ogni possibile esito del gioco corrisponde univocamente ad uno stato del mondo. L'obiettivo e quello di costruire una funzione di risultato (meccanismo) che fornisce gli agenti, con incentivi a prendere azioni in modo che il "vero" risultato e attuato. Senza alcuna prova concreta nella comunicazione modello e privo di valore. Tuttavia, se lasciare che gli agenti ricevere le prove per dimostrare lo stato, con una probabilita infinitesimale siamo in grado di indurre l'attuazione veritiera in ogni equilibrio. Il modello assomiglia ad una situazione di concorrenza tra gli avvocati e il nostro principale risultato dimostra ampie possibilita di aggregazione delle informazioni nell'ambito della procedura di contradditorio.

Nel secondo capitolo si considera una partita di prova tra un imputato e un giudice e si concentrano sugli effetti del diritto del convenuto di rimanere in silenzio. Forniamo una giustificazione del motivo per cui non esiste alcuna norma contro inferenza negativi dal silenzio in procedura civile.

Il terzo capitolo riguarda la corporate governance. Si dimostra che, al di vendita iniziale di parti, uno dei fondatori di controllo possono avere gli incentivi negativi in termini di segnalazione espropriazione basso al di fuori degli azionisti.

Competition Among Advocates: How to Induce a Majority to Speak the Truth

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Abstract: An uninformed decision maker has to make a ranking of three agents. Each agent knows the true ordering but care only about his own position in the decision maker's ranking. Initially, the agents independently receive evidence to verify the truth. Anyone not receiving evidence can prove nothing. The agents simultaneously make a declaration and later disclose evidence. We show how to implement the correct ranking in every equilibrium when the probability to receive evidence is arbitrarily small. This result is in stark contrast to the case where evidence is never realized. With only two agents or complete information about provability we can implement the true ranking in every equilibrium only if evidence is realized with certainty.

1. Introduction

As observed in Dewatripont and Tirole (1999) the decision process in many organizations (corporations, government, etc.) is driven by competition among advocates of special interests. The archetypal example is the adversarial system in judicial procedure. Outside the legal sphere deliberation often takes a quasi-judicial form. In regulatory hearings competing experts lobby for their own cause and proxy advocates. In companies heads of devisions compete for budgets without much regard to the overall profits. Many board and committee members are elected to defend special interests while other members are more neutral and base their decisions on the arguments made.

In this paper competition among advocates is modeled as a ranking game. An uninformed decision maker has to make a relative assessment of three agents. The agents possess all the soft information necessary to conclude on the true ordering (the state). However, their goals are independent of this information and consist simply in obtaining the highest possible position in the ranking chosen by the decision maker. There is also an amount of hard information in the model. Each agent independently and privately receive evidence that allows him (her) to verify the true ranking of the agents. Anyone who did not receive evidence can prove nothing. First, the agents simultaneously make a statement about the state (cheap talk) and later they voluntarily disclose evidence. From this procedure a ranking is chosen. Initially, the decision maker commits to a decision rule instructing the agents how possible combinations of statements and evidence disclosure maps into outcomes.

The following example illustrates the model. Three individuals have been caught "red handed" committing a crime together. Only the suspects know the roles taken on by each of them i.e. who was first, second, and third in wrongdoing. The suspects independently talk to the police and later they can present evidence in a joint trial (in this example the suspects' attorneys compete for lower rankings not higher). Another example is: A manager has to make an evaluation of a group of employees. The employees' career development depend on this assessment and how they compare with the others. From individual interviews with the manager the employees can present both soft and hard information regarding their own performance and the performance level of their co-workers.

Our focus is, how to construct a mechanisms that provides the agents with incentives to take actions so that the true ranking is always implemented. This is not easy as there is no way to be sure that evidence will be disclosed (or even worse that evidence exists) and we are only allowed to reward and punish agents through variations in the rankings.

Our main finding supports the adversarial process as a means of information aggregation. We demonstrate how to implement true rankings in every equilibrium when the probability that the agents receive evidence is arbitrarily small. Not surprisingly, in the instance where evidence is never realized (pure cheap talk) the communication is worthless. We show that if the agents, ex ante, observe whether the other agents have evidence then truthful implementation in every equilibrium is impossible unless evidence is realized with certainty. This result stands in contrast to initial disclosure rules that require disputing parties to disclose information about whatever evidence they plan to present.[1] When we consider the ranking game played by only two agents (e.g. one defendant and one plaintiff in a liable/no-liable issue) there is no way, for a single equilibrium, we can assure that the correct decision will be taken (the defendant pay damages if and only if he is truly responsible). Thus, the inclusion of one more informed "advocate" has a huge impact.

To obtain the main result for three agents we construct a decision rule (outcome function) such that if a majority agree that agent i ranks first the ranking declared by agent i is implemented, unless someone proves that i's true ranking is second or third. From this we can already tell that an equilibrium exists where the agents report truthfully and correct rankings are implemented. In this situation none of the agents can unilaterally change

[1] See U.S. Federal Rules of Civil Procedure rule 26(a) and U.S. Federal Rules of Criminal Procedure rule 16(a) and (b).

the majority constitution and agent i's declaration is irrefutable.

The more difficult part is to show that no other equilibrium exists where something else occurs. Suppose for the moment that the agent who is first in the true ranking always declares truthfully. One feature of our ranking mechanism is that when the agents disagree about who ranks first and no evidence is disclosed an equal randomization over the possible outcomes is made. This randomization provides the agents with an expected payoff corresponding to the payoff from ranking second.[2] In case of disagreement and disclosure of evidence an outcome is chosen so that the agent who is second in the true ranking is ranked third. Another key feature is that whenever two agents are detected in falsely declaring a state where agent i ranks first a randomization is made so that these two agents will be ranked second and third with equal probability. Thus, a common theme is that detected liars are punished.[3] One perhaps undesirable feature is that (off equilibrium path) the decision maker commits to wrong rankings when in fact the true state has been verified.

The point is that with this type of ranking mechanism when two agents falsely declare a state where agent i is first then one of these agents is better off switching strategy. Further, in case the agents disagree about who ranks first the agent who is second in the true ranking has an incentive to deviate.

To provide more intuition on this part consider the following two critical situations. First, suppose we have a disagreement situation. What seems most natural is that the second ranked agent declares a state where he ranks first and the third ranked agent declares a state where he is first. Here, the agent who is second in the true state has an obvious incentive to deviate and declare truthfully. If no evidence is disclosed he is equal off as his expected payoff is the same whether he deviates or not. If evidence is disclosed he is strictly better off announcing the true ranking as he will be ranked second (i.e. the first and second ranked agents declare truthfully) while lying leads to being ranked third. Notice, at least one of the two other agents have an

[2]We later discuss the implications of this assumption.

[3]In legal procedure sanctions against parties who have been detected in lies are widely used, see e.g. U.S. Sentencing Guidelines Manual 2J1.3 (2004). Often, a contradicted testimony will trigger the jurys' adverse inference.

incentive to disclose evidence in case of disagreement.

Second, consider the critical configuration where the second and third ranked agents declare the state where these two agents rank first and second, respectively. Here, the third ranked agent has an incentive to deviate. Consider the deviation where the agent who is third in the true ranking instead declare a state where he ranks first. This move will cause the disagreement formation. If no evidence is disclosed he will receive the same expected payoff. If evidence is disclosed then by not deviating he will be disproven, and punished, together with the agent who second in the true ranking. However, by deviating he will be ranked at least second following disagreement and disproval of the agent who is second in the true ranking.

We next compare our results to the literature on full disclosure and implementation with hard evidence in settings where the agents have state independent preferences. In our game state independent preferences corresponds to the fact that an agent's payoff from some ranking chosen by the decision maker, does not at all depend on his true ranking.

In seminal papers by Grossman (1981), Milgrom (1981), and Milgrom and Roberts (1986) it has been argued that by adopting skeptical beliefs towards a party who is withholding information it is possible to force disclosure of all information. However, as discussed in papers like Shin (1994) and Lipman and Seppi (1995) the "unravelling" argument relies on the assumption that the parties can always verify the truth. Without this assumption we cannot be sure whether non-disclosure is due to strategic evidence management or simply because evidence does not exists, or it does not exists to everyone.

In a general environment Ben-Porath and Lipman (2009) study implementation with evidence where the agents commonly observe the state. They show that a condition called "measurability" is necessary and sufficient for full implementation given any preference profile including state independent. If the planner wish to implement a unique outcome for each state then "measurability" implies that enough hard information exists so that if the agents disclose all their evidence then the true state can immediately be deduced. A similar result is obtained in Kartik and Tercieux (2009).[4] In the present pa-

[4]For other papers on strategic information revelation including hard evidence and state

per we deal with situations where measurability does not hold and possibly, perhaps most likely, the agents cannot prove anything. In Ben-Porath and Lipman (2009) and Kartik and Tercieux (2009) the agents' set of verifiable messages is common knowledge.

To our knowledge no other paper has demonstrated truthful implementation in every equilibrium when the agents have state independent preferences and measurability does not hold and the number of outcomes is equal to the number of states. In this respect, Deneckere and Severinov (2008) show that unique implementation is possible (generally) if one agent speaks the truth with some small probability and an outcome exist that is extremely bad for all the agents.

2. The Game

The game is played by three agents ($i = 1, 2, 3$). A state of the world is an ordinal ranking of the agents. More precisely, a state $s \in S$ is a vector with three entries where the i'th entry denote the ranking of agent i. Denote the true state by s^*. We refer to the agent who is first, second, and third in the true ordering as the "first", "second", and "third" - agent. The table below show each agent's ranking for the six possible states.

	s_1	s_2	s_3	s_4	s_5	s_6
Agent 1	1	1	2	2	3	3
Agent 2	2	3	1	3	1	2
Agent 3	3	2	3	1	2	1

Table 1: Possible states

An outcome, $x \in S$, is an ordinal ranking of the agents i.e. a vector with three entries where the i'th entry (x^i) denote the ranking of agent i. Let $x_n = s_n$, for $n = 1, .., 6$. If the outcome is $x = s^*$ we say that the true state

independent preferences, see Green and Laffont (1986), Okuno-Fujiwara, Postlewaite, and Suzumura (1990), Fishman and Hagerty (1990), Seidmann and Winter (1997), Glazer and Rubinstein (2001, 2004, 2006), Bull and Watson (2004, 2007), Deneckere and Severinov (2004), Forges and Koessler (2005, 2009), and Sher (2008).

has been implemented. We consider the simple case where agent i's payoff is $\Pi^i(x) = 3 - x^i$. Notice that an agent's payoff does not depend on the state nor on the other agents rankings. The agents are risk neutral.

An outcome function, β, maps any possible terminal history of the game to an outcome, or probability distribution over outcomes. As will become clear from the description below a terminal history is any profile of cheap talk followed by a profile of disclosure decisions, $h^T = [s^1, s^2, s^3, d^1, d^2, d^3]$. The agents observe the outcome function before the game starts. The game has three stages.

Stage 1 (Nature's move). First Nature chooses a state, s^*, which is observed by all the agents. Consider any non-degenerate probability distribution governing the realization of s^*. Once s^* is realized Nature chooses a type for each agent. Types are *private* information (the agents observe their own type but not the others' type). There are two types. If an agent is the "evidence" type he has evidence that allows him to prove s^*. If an agent is the "no-evidence" type he can prove nothing. With probability $\mu \in [0, 1]$ agent i is the "evidence" type and with probability $1 - \mu$ he is the "no-evidence" type. Nature's type distribution is independent across agents and states.

Stage 2 (Declarations). The agents simultaneously declare a state $s \in S$. Denote the declaration from agent i by s^i. There are no direct costs from lying. Hence, the declarations are cheap talk.

Stage 3 (Evidence disclosure). After observing the declarations, the parties simultaneously make a disclosure decision, d^i. If agent i is the "evidence" type then $d^i \in \{"no", s^*\}$, where $d^i = "no"$ is an empty message proving nothing and $d^i = s^*$ means that agent i disclose evidence that proves s^*. If agent i is the "no-evidence" type he has no choice than to send the empty message, $d^i \in \{"no"\}$. With this representation it is implicit that an agent cannot prove if he did not receive evidence. Further, if someone has evidence he is free not to disclose it. We assume no costs associated with processing or disclosing hard information.

A strategy for agent i, σ^i, gives for any state and type of agent i a declaration, s^i, and for any profile of declarations a disclosure decision, d^i. We allow for mixed strategies. After observing the declarations and before disclosing evidence, the agents update their beliefs about the other agents types. Let ϕ^i denote agent i's posterior beliefs about whether each of his opponents have evidence.

When $\mu \in (0,1)$ any outcome function induces a Bayesian game. The equilibrium notion for the induced game is weak perfect Bayesian equilibrium (weak PBE). In weak PBE (i) the strategy profile σ is sequential rational given belief system ϕ. (ii) The system of beliefs ϕ is derived from σ using Bayes' rule whenever possible. When $\mu \in \{0,1\}$ the game is of complete information and the equilibrium notion is subgame perfect Nash (SPNE).

Notice that each realization of a state initiates a proper subgame (six in total when $\mu \in (0,1)$). The game as a whole is finite as the number of states, types, and possible actions to each agent, both at the declaration stage and evidence stage, is indeed finite. Moreover, the game is clearly of perfect recall. In finite games with perfect recall at least one "trembling hand perfect equilibrium" exist (Selten 1975). A trembling hand perfect equilibrium is also a sequential equilibrium which is both weak PBE and SPNE (see Mas-Colell, Whinston, and Green 1995).

3. Analysis

Our focus is on the amount of hard information, measured by μ, that is necessary and sufficient for a *robust outcome function* (ROF) to exist. A ROF guarantees that the true ranking is implemented in every equilibrium:

Definition 1. *For $\mu \in (0,1)$ a ROF induces a game for which equilibrium play (in every weak PBE) implements x_n if and only if $s^* = s_n$. When $\mu \in \{0,1\}$ a ROF induces a game for which equilibrium play (in every SPNE) implements x_n if and only if $s^* = s_n$.*

When $\mu = 0$ the game can be reduced to a realization of a state and the declarations. Our first result simply states that when $\mu = 0$ for any induced game the set of equilibria across each subgame starting from a different state, is the same. Hence, looking at equilibria of the game as a whole nothing can be deduced about the true state and communication is redundant.

Proposition 1. *When $\mu = 0$, for any induced game the set of Nash equilibria is identical across any two subgames starting from s_n and s_m, $n \neq m$.*

Proof. Proposition 1 follows immediately from the fact that the agents' feasible messages and payoffs are state independent when $\mu = 0$. □

Our next result is more surprising and positive in terms of information transmission from the informed agents.

Proposition 2. *A ROF exist if $\mu > 0$.*

Proof. See appendix.

In the proof of proposition 2 we specify an outcome function, $\hat{\beta}$, and consider any possible case that may lead to a wrong outcome and rule out these situations as part of a weak PBE. To provide the intuition of proposition 2 we sketch an outcome function that encompass $\hat{\beta}$ and consider special cases leading to wrong outcomes. To make it simpler we assume in the following that the "first" agent always declare truthfully. This is without loss of generality.[5] The ranking mechanism is constructed such that if a majority of the agents declare a state where agent i ranks first then the state declared by agent i is implemented, unless someone proves that agent i is not "first". A key point is that whenever two agents falsely declare a state where agent i ranks first we can provide one of them with an incentive to deviate.

[5] For the outcome function specified in the proof the "first" agent can never be strictly better off declaring untruthfully and if he is disproven he will be ranked third.

Furthermore, in case the agents disagree about who ranks first the "second" is better off switching strategy.

Let $\mu > 0$ and consider an outcome function characterized as follows: (i) If two or more agents declare a state where agent i ranks first then the state declared by agent i is implemented, unless evidence contradicts that agent i is "first". (ii) If two agents declare a state where agent i ranks first and evidence verifies that agent i is *not* "first" then these two agents will be ranked second and third with equal probability. (iii) If none of the agents agree about who ranks first (disagreement) and evidence proves that the "second" agent was lying then he will be ranked third. Here, the "first" and "third" agent will be ranked first and second with equal probability. (iv) If the agents disagree and no evidence is disclosed then each possible outcome is chosen with equal probability (the agents expected payoff is 1).

Suppose $s^* = s_1$. If agent 2 (the "second" agent) declare s_1 and agent 3 declare s_4 then x_1 is the outcome as agents 1 and 2 declare s_1. The payoff to agent 2 is 1. This is a stable configuration. Obviously agent 1 has no interest in deviating and agent 3 cannot affect the outcome at all. If agent 2 instead declare s_4 or s_6 then independent of the evidence disclosure he will receive an expected payoff strictly less than 1. If agent 2 declare s_3 or s_5 then in case no evidence is disclosed he obtains payoff 1 (see (iv)) and if evidence is disclosed payoff 0 (see (iii)). As agents 1 and 3 have incentives to disclose evidence in such instance, given they have evidence, agent 2 is strictly worse off. This also tells us that disagreement is not stable as agent 2 is better off switching to s_1.

The most critical candidate for untruthful implementation is when agents 2 and 3 declare s_5. With this formation and if no evidence is disclosed then x_5 will be the outcome leaving agents 2 and 3 strictly better off than with x_1. If they are disproven they will each receive an expected payoff equal to 0.5. If μ is low this situation is still attractive for agents 2 and 3 compared to x_1 implemented with certainty. However, when agent 3 anticipates that agent 2 declare s_5 he can make a profitable deviation! If agent 3 instead declare s_4 then if no evidence is disclosed he is equal off (he still obtains payoff 1) while if evidence is disclosed he is strictly better off, see (iii). As agent 1 has an incentive to disclose evidence both in case agents 2 and 3 declare s_5 and when the agents disagree about who ranks first, we get that the proposed formation is unstable.[6]

Remark. We defined the payoffs from ranking first, second, and third to be 2, 1, and 0, respectively. Part of the reasoning leading to full information implementation for any positive μ relied on a randomization between outcomes providing the agents with an expected payoff that equals the payoff from ranking second. This equivalence is not immaterial.

Consider the outcome function sketched earlier. Suppose $s^* = s_1$ and the equal randomization between outcomes yields an expected payoff *higher* than the payoff from being ranked second. In this case we cannot guarantee, for a sufficiently small μ, that the "disagreement" configuration where agent 2 declare s_3 or s_5 and agent 3 declare s_4 or s_6 is not part of an equilibrium. Again, there is no loss in assuming that agent 1 declare s_1. If agent 2 declare s_3 or s_5 (disagreement) and no evidence is disclosed he will receive a higher payoff than if he declare s_1 (x_1 is implemented and agent 2 is ranked second). If agent 2 declare s_3 or s_5 and evidence is disclosed he will be ranked third. If μ is low enough agent 2's expectancy from disagreement is still higher than his payoff following x_1.

Likewise, if the equal randomization between outcomes yields an expected payoff *lower* than the payoff for ranking second we cannot be sure that the situation where agents 2 and 3 declare s_5 is not stable. For a sufficiently low μ agent 3's deviation to s_4 is not profitable. If no evidence is disclosed agent 3 receives a higher payoff from declaring s_5 while if evidence is disclosed he is better off declaring s_4 or s_6 (disagreement).

Complete information about types. What happens if we let the agents, before making their statements, get to know whether the other agents have evidence? It turns out that robust implementation becomes impossible

[6] One possibility that could leave agent 3 with a positive equilibrium payoff is if he could move *before* agent 2 and "commit" to declaring s_5 inducing agent 2 to also announce s_5. The simultaneous message sending precludes such an opening.

unless $\mu = 1$. In the complete information game the players can tell when they are on a game-path where threats of "low ranking" following disproval, are empty.

Proposition 3. *With complete information about provability a ROF exists if and only if $\mu = 1$.*

Proof. Let $\mu \in [0, 1)$. The game is of complete information. Consider the six subgames initiated by different states and the evidence realization where none of the agents have proof. The set of equilibria across these subgames must be the same and robust implementation is impossible. Let $\mu = 1$. Consider $\hat{\beta}$: (1) If agent 1 or 2 disclose evidence the true state is implemented. (2) If neither agent 1 or 2 disclose evidence then agents 1 and 2 will be ranked second and third with equal probability. It is straightforward that $\hat{\beta}$ is robust as in any equilibrium either agent 1 or 2 will disclose evidence $\square$

Two agents. Suppose now our ranking game is played by only two agents. In this case there are two states: $s_1 = [1, 2]$ and $s_2 = [2, 1]$ and two outcomes: $x_1 = [1, 2]$ and $x_2 = [2, 1]$. The payoff to agent 1 (2) from x_1 is 1 (0) and from x_2 it is 0 (1). All other aspects of the two player game parallels the three player game described in section 2. A necessary condition for a ROF to exist is that $\mu = 1$. In fact, no single equilibrium exist that always implement s^*, unless $\mu = 1$. The problem is that if we want to rank agent 1 first whenever this is justified we need to make sure this can be attained when agent 1 does not have evidence. If we do this we automatically allow for the possibility that agent 1 is ranked first when it is unjustified.

Proposition 4. *With two agents and $\mu < 1$ no outcome function exists such that, for one equilibrium of the induced game, x_1 is implemented if and only if $s^* = s_1$. A ROF exists if $\mu = 1$.*

Proof. Let $\mu < 1$. By contradiction. Suppose the outcome function, $\bar{\beta}$, is such that for at least one equilibrium of the induced game the true state is always implemented. (i) Suppose $\bar{\beta}$ is such that if agent 2 declare s_1 or s_2 then irrespective of agent 1's declaration and if no evidence is disclosed then x_1 is implemented with probability $p < 1$. If this is true then agent 2's equilibrium payoff (in any equilibrium) conditional on $s^* = s_1$ must be strictly higher than 0 (x_2 is chosen with positive probability). If this was not true and in some equilibrium, conditional on $s^* = s_1$, the outcome is x_1 with probability 1, then agent 2 could profitably deviate and in the instance that agent 1 does not have evidence be guaranteed an expected payoff higher than 0. Hence, if $\bar{\beta}$ is like in (i) we have a contradiction.

Now suppose (i) is not true and thus $\bar{\beta}$ is such that there exist an agent 1 declaration, say s_1, so that if sent and no evidence is disclosed then surely x_1 is the outcome irrespective of agent 2's declaration. In this case we instead get that in any equilibrium, conditional on $s^* = s_2$, agent 1's expected payoff is strictly higher than 0. When $s^* = s_2$ agent 1 can simply declare s_1 and refrain from disclosing evidence, if he has any, and if agent 2 did not receive evidence then x_1 is implemented. This completes the contradiction.

Suppose $\mu = 1$. It is straightforward that a ROF exists, just let the outcome be x_1 if and only if agent 1 proves that the state is s_1 $\square$

5. Conclusion

In this paper we have studied robust information revelation in a game where the informed agents have conflicting and state independent preferences. We coupled perfect information about the underlying state with incomplete information about provability and exposed surprising possibilities for information aggregation with minimal hard information. The model resembles a situation of competition among advocates that can be applied to decision processes in many organizations (both at the private and government level). In turn our main result helps to explain the prevalence and strength of the adversarial procedure.

The model has several interesting extensions. One possible array for future research would be to consider a setting that allows for more than three agents and where the agents obtains bits of evidence that does not completely reveals the true state. Another extension is to consider the possibility that the agents only know parts of the information relevant to the decision maker. Some agents may be prone to observe specific aspects of the true state (e.g. union lobbyists know the actual facts relating to how workers are affected by some legislation). In a simple model, we could relax the common knowledge assumption about this information asymmetry and study optimal debating procedures. Finally, we could study the effects of restrictions on allowable outcome functions. These restriction could relate to limitations due to bounded rationality of the decision maker or in terms of off-equilibrium-path credibility (or maybe fairness considerations).

Appendix

Proof of proposition 2. Consider the following outcome function $\hat{\beta}$:

(1) If agent i proves that agent $j \neq i$ was first in ranking and agent j declared falsely (i.e. $s^j \neq s^*$), then $x = [x^j, x^i, x^k] = [3, 1, 2]$ is implemented, where $k \neq i, j$. If also agent k disproves agent j then $x = [x^j, x^i, x^k] = [3, 1, 2]$ and $x = [x^j, x^i, x^k] = [3, 2, 1]$ are implemented with equal probability.

(2) (Given the above has not occurred) If the declarations are such that none of the agents agree about who ranks first and agent i proves that agent $j \neq i$ was second in ranking and j declared falsely then $x = [x^j, x^i, x^k] = [3, 1, 2]$ is implemented. If also agent k disprove agent j then $x = [x^j, x^i, x^k] = [3, 1, 2]$ and $x = [x^j, x^i, x^k] = [3, 2, 1]$ are implemented with probability $1/2$.

(3) (Given none of the above) If agent i and agent j declare a state where agent i is first in ranking and agent k proves that they were both lying, and k declared truthfully then $x = [x^j, x^i, x^k] = [3, 2, 1]$ and $x = [x^j, x^i, x^k] = [2, 3, 1]$ are implemented with equal probability. If also agent j disclose evidence, then $x = [x^j, x^i, x^k] = [2, 3, 1]$ is chosen with probability $2/3$ and $x = [x^j, x^i, x^k] = [3, 2, 1]$ with probability $1/3$.

(4) (Given none of the above) If two or more agents declare a state where agent i is first in ranking then agent i decides the outcome i.e. $x = s^i$.

(5) Otherwise, each possible outcome is chosen with the same probability

(1/6). In this case the agents expected payoff is 1.

When $\mu = 1$ the proof is covered by the proof of proposition 3. Let $\mu \in (0, 1)$ and consider the Bayesian game induced by $\hat{\beta}$. In the following we consider the subgame starting from the realization of s_1. We show that equilibrium play, in any equilibrium, implement x_1. We argue that the same type of game is played, and the parallel logic applies, when we consider the subgame initiated by $s_{n\neq 1}$. We conclude that, for the whole game, $\hat{\beta}$ is robust.

Step 1. In any weak PBE we must have agent 1 declaring s_1 with probability 1 when he has evidence.

By contradiction. Suppose in equilibrium agent 1, following $\bar{\sigma}^{1*}$, declare s_1 with probability $p < 1$ when he has evidence. Consider the alternative strategy $\tilde{\sigma}^1$ where agent 1 always declare s_1 and disclose evidence whenever possible. It is clear from $\hat{\beta}$ that it is a weakly dominant action for agent 1 to declare truthfully. Further, agent 1 can never be worse off from disclosing evidence. Thus, we need to show that the deviation is strictly profitable. Consider the event that both agent 2 and 3 have evidence and agent 1 declare untruthfully following $\bar{\sigma}^{1*}$. If agent 2 disclose evidence he will be guaranteed an expected payoff of at least 1.5 (disproving agent 1, see $\hat{\beta}$ (1)). The same is true for agent 3 if he submit evidence. By inspection of $\hat{\beta}$ and given a false declaration from agent 1 we know that there is no other terminal history that provides both agent 2 and 3 with an expected payoff equal to 1.5. Hence, by sequential rationality agent 1 will be disproven with positive probability in the proposed equilibrium. In this instance agent 1 is strictly better off declaring s_1 and disclosing evidence. Put together, the deviation $\tilde{\sigma}^1$ is profitable and $\bar{\sigma}^{1*}$ cannot be part of an equilibrium.

Step 2. In any weak PBE we must have agent 1 declaring s_1 with probability 1 when he is the "no-evidence" type.

By contradiction. Suppose in equilibrium agent 1, following $\bar{\sigma}^{1*}$, declare

s_1 with probability $p < 1$ when he is the "no-evidence" type. Consider the alternative strategy $\tilde{\sigma}^1$ which is identical to $\bar{\sigma}^{1*}$ except that when agent 1 is the "no-evidence" type he declare s_1 with probability 1.

Declaring truthfully following $\tilde{\sigma}^1$ is weakly dominant. We also know from step 1 that in equilibrium, whenever agent 1 lies he is disproven with positive probability resulting in payoff zero. Consider the deviation $\tilde{\sigma}^1$ and the event that both agent 2 and 3 have evidence. We argue that agent 1's expected payoff must be strictly positive, making the deviation a strict improvement. There are two scenarios that could potentially leave agent 1 with payoff zero. Suppose agent 2 and 3 declare a state where agent 3 ranks first and agent 3 declare a state where agent 1 ranks third. By step 1 we know that in equilibrium agent 1 declare s_1 when he has evidence and by sequential rationality he will disclose evidence following such declarations. By $\hat{\beta}$ (3), agent 2 is strictly better off disclosing evidence when agent 1 disclose evidence and he is indifferent if agent 1 does not disclose evidence. When agent 2 disclose evidence agent 1 receives a positive payoff. Suppose instead agent 2 and 3 declare a state where agent 2 ranks first then, by sequential rationality and $\hat{\beta}$ (2), agent 3 will disclose evidence resulting in a positive payoff to agent 1.

Step 3. In any weak PBE we cannot have agent 2 declaring s_4 or s_6 with positive probability.

By contradiction. Suppose in equilibrium agent 2, following $\bar{\sigma}^{2*}$, declare s_4 and/or s_6 with positive probability for some, or both, types. Consider $\tilde{\sigma}^2$ which is like $\bar{\sigma}^{2*}$ except that instead of declaring s_4 or s_6 agent 1 announce s_1 and disclose evidence (if he has any) following such declaration.

If agent 2 declare s_1 he will receive payoff 1 (by step 1-2 and $\hat{\beta}(4)$). If agent 2 declare s_4 or s_6 he will at most receive an expected payoff equal to 1 (by step 1-2 and $\hat{\beta}(2)$-(5)). We can immediately deduce that in the equilibrium agent 3 never declare s_1 or s_2 with positive probability as this provides him with payoff zero and since agent 2 declares s_4 and/or s_6 with positive probability he can receive a positive expected payoff from declaring something different. By this and sequential rationality we know that agent

1 will disclose evidence (whenever he has any) when agent 2 declare s_4 or s_6. In this case agent 2 will be disproven ($\hat{\beta}(2)$) or disproven together with agent 3 ($\hat{\beta}(3)$) and receive a payoff strictly less than 1. Thus, agent 2 is strictly better off with $\tilde{\sigma}^2$ and we have a contradiction.

Step 4. In any weak PBE we cannot have both agent 2 and 3 declaring a state where agent 2 ranks first.

By contradiction. Suppose we have a weak PBE $(\bar{\sigma}^{1*}, \bar{\sigma}^{2*}, \bar{\sigma}^{3*}, \bar{\phi}^*)$ where agent 2 and 3, with some positive probability, declare a state where agent 2 ranks first. Consider the deviation $\tilde{\sigma}^3$ which is the same as $\bar{\sigma}^{3*}$ except that whenever agent 3 would declare s_3 or s_5 he instead announce s_6 and disclose evidence whenever he has any. We know from step 1 and 2 that agent 1 always declare s_1. We know from step 3 that in equilibrium agent 2 never declare a state where agent 3 ranks first.

If agent 2 declare s_1 or s_2 agent 3 is indifferent about any declaration (he receives payoff zero no matter what). In the following we argue that when agent 2 declare s_3 or s_5 agent 3 is strictly better off declaring s_6. When agent 3 declare s_6 he will, independent of the evidence disclosure, receive an expected payoff of at least 1. If agent 3 declare s_3 or s_5 he will at most receive payoff 1 and in case agent 1 disclose evidence his payoff is strictly less than 1. By sequential rationality agent 1 will disclose evidence, if he has any, when agent 2 and 3 declare a state where agent 2 ranks first ($\hat{\beta}$ (3)). Hence, $\tilde{\sigma}^3$ is strictly preferable and $(\bar{\sigma}^{1*}, \bar{\sigma}^{2*}, \bar{\sigma}^{3*}, \bar{\phi}^*)$ cannot be an equilibrium.

Step 5. For any weak PBE we can never have agent 2 declaring s_3 or s_5.

By contradiction. Suppose in some weak PBE agent 2, following $\bar{\sigma}^{2*}$, declare s_3 or s_5 with positive probability for some, or both, types. Consider the deviation $\tilde{\sigma}^2$ where agent 2 always declare s_1 and disclose evidence whenever possible. It is clear that agent 3 will never declare s_1 or s_2. From this and by step 1-4, we have that agent 2 can at most receive an expected payoff equal to 1 from declaring s_3 or s_5. Moreover, by sequential rationality we know that agent 1 will disprove agent 2, following $\hat{\beta}$ (2), whenever he has the opportunity. When this happens agent 2 receives payoff zero. If instead agent 2 declare s_1 following $\tilde{\sigma}^2$ he will receive a certain payoff equal to 1.

Step 6. In any (and at least one) weak PBE the outcome is x_1.

The game is finite and of perfect recall and thus, at least one "trembling hand perfect equilibrium" exists (Selten 1975). Any such "perfect equilibrium" is also a weak PBE. By step 1-5 we have that in any weak PBE agent 1 declare s_1 and agent 2 never declare s_3, s_4, s_5, or s_6 and hence the equilibrium outcome cannot be anything but x_1 (see $\hat{\beta}$ (4)).

Step 7. For the game as a whole, in any weak PBE the outcome is x_n iff the true state is s_n.

If we consider a different subgame starting from $s_{n\neq 1}$ we can apply the same reasoning as throughout the steps 1-6 to conclude that x_n is implemented in every equilibrium. For example, if the state is s_3 we can use the same logic to establish that the "first" agent (now agent 2) always declare s_3 and the "second" agent (agent 1) declare a state where agent 2 ranks first. This conclusion hinges on the symmetric game structure and the fact that $\hat{\beta}$ is such that for any terminal history the expected payoff accruing to the "first" and "second" agent never depend on which of the agents (1, 2, or 3) is actually "first", "second", or "third" $\square$

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Optimal Judge strategies: An Analysis of the Right to Silence

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Abstract: We study a simple trial game between a judge and a defendant. Initially the judge commit to a decision rule: depending on a piece of hard evidence and a statement from the defendant the result is acquittal or conviction. In equilibrium the judge minimizes the probability of miscarriages of justice, for some standard of proof, given that the defendant maximizes his chances of acquittal. We show that there always exist an equilibrium decision rule that is also ex post optimal. We find that (i) when the prior probability of guilt is low relative to the burden of proof the possibility of cheap talk (the defendant's statement) benefits the judge. (ii) When introducing a "right to silence" the judge may become worse off, the innocent defendant is always equal off, and the criminal may benefit from such a right. (iii) With mandatory pretrial disclosure the judge and the innocent defendant are never strictly better off while the criminal can be both better and worse off. (iv) The same effects as in (iii) obtains if the innocent defendant knows nothing more about the accusations except that he is innocent.

1. Introduction

In this paper we study a simple trial game played by a defendant and a judge. The defendant is accused of committing a crime and he is guilty in one out of three possible states of the world. Only the defendant knows the state. The game unfolds as follows: First, hard evidence is automatically displayed by an earnest prosecutor. The evidence rules out one of the false states. Thereafter, the defendant makes a statement. Importantly, the defendant does not observe the evidence realization before making his statement.

We let the judge choose (commit to) a decision rule first. A decision rule attach a verdict (acquit/convict) to any possible combination of a state ruled out and a message from the defendant. The judge seeks to minimize the probability of miscarriages of justice. The defendant's objective is to be acquitted whether he is innocent or not. We identify equilibria of such a game and show that there always exists an equilibrium where the judge strategy (decision rule) is credible i.e. the strategy is also ex post optimal.

In equilibrium, when the prior probability of guilt is low relative to the burden of proof, the judge puts weight on the defendants "cheap talk" message. A positive inference can be made if the defendant's claim about the true state is not inconsistent with the evidence. At the same time, an adverse inference can be made if his statement is contradicted by the evidence. In legal procedure sanctions against parties who have been disproven are widely used.[1]

We then consider the effects of a defendant's "right to silence". The right to remain silence, as constitutionalized in most Common law countries, gives a suspect the right not to answer questions when interrogated by the police or when testifying at trial. In our game, when the prior probability of guilt is lower than burden of proof the judge is forced to acquit following a silent message from the defendant. In this way, the right to silence constraints the set of decision rules available to the judge. We find that under no circum-

[1] U.S Federal Law defines perjury as a felony. See also U.S. Sentencing Guidelines Manual 2J1.3 (2004). Moreover, contradicted statements can trigger a jury's adverse inference.

stances can the judge benefit from a right to silence and sometimes he is worse off. When the prior probability of guilt is not too high and the burden of proof not too low the defendant is acquitted as long as he remain silent. By this, the criminal avoids the risk that his testimony is disproven which would lead the judge to infer guilt and trigger an adverse inference. While the criminal may be strictly better off with a right to silence we find that the innocent defendant is always equal off.

These results offers an explanation to why countries like the U.S. allow adverse inference from silence in civil trials[2] but not in criminal trials.[3] Whereas the prior probability of guilt in lawsuits is typically close to a fifty/fifty assertion this is far from the case in criminal trials. The progress in forensic sciences has made it possible to, a priori, assert innocence or guilt with much accuracy and self exonerating defendants are taken to court only if the probability of guilt is very high.[4] With a high prior probability of guilt the defendant is reluctant to remain silent as other evidence alone is likely enough to establish guilt beyond a reasonable doubt. The criminal's choice is rather between confession or making a persuasive exculpatory testimony and hope the prosecution is unable to contradict the lies.[5]

Another legal right given to defendants require the prosecutor to share evidence with the defendant before the trial begin. In our model this right means that the defendant obtains knowledge about which state has been ruled out. Such pretrial disclosure can have a negative effect on the judge's expected equilibrium payoff. When the criminal learn which false non-incriminating statement will never be disproven any inference from the defendant's statement loses value. We find that, depending on the prior probability of guilt

[2]In *Baxter v. Palmigiano*, 425 U.S. 308 (1976) the court held that the protection against adverse inference from silence only apply to criminal cases.

[3]See *Miranda v. Arizona*, 384 U.S. 436 (1966).

[4]Around 1 percent of felony defendants are acquitted after trial, see U.S. Dep't of Justice, Bureau of Justice Statistics, Sourcebook of Criminal Justice Statistics (1999).

[5]Between eighty and ninety percent of suspects actually talk to the police, see Cassell and Hayman (1996) and Leo (1996). Leo (1999) show that more than 42 percent of questioned suspects incriminate themselves. U.S. Dep't of Justice, Bureau of Justice Statistics, Sourcebook of Criminal Justice Statistics (1999) find that this percentage is around 64 percent. Cassell and Hayman (1996) find that more than 45 percent of questioned suspects deny guilt or make other non-incriminating statements. See also generally Bibas (2009).

and the burden of proof, the criminal can either lose or gain from pretrial disclosure while the innocent defendant is either worse off or indifferent. Furthermore, with pretrial disclosure the judge is always unaffected by the introduction of a right to silence.

In the way we have constructed the model it is assumed that the defendant is perfectly informed about the state of the world - as if he was there at the scene of the crime. Suppose instead that the innocent defendant does not observe which of the two "innocent" states occurred. In this case the innocent defendant cannot send distinct messages depending on which of the two "innocent" states occurred. We find that the effects of the innocent defendant's ignorance exactly corresponds to the effects from introducing pretrial disclosure - namely the cheap talk stage becomes redundant.

2. Related literature

Most relatedly is Seidmann (2005). Seidmann study equilibria of a signaling game between a suspect and a judge where the judge chooses his verdict after hearing the suspect's statement and observing the realization of some hard evidence. Two regimes are evaluated: the English game where adverse inference from silence is allowed and an American where adverse inference is not permitted. Seidmann show that a right to silence can reduce convictions of innocent suspects. Availing the right constraints the jury to certain outcomes. Criminals may find silence more attractive than perjuring statements and thereby separate themselves from truth-telling innocent suspects. When the society's preferences for convicting innocent suspects relative to acquitting criminals are different from the court's then a right to silence can increase social welfare. This in turn may explain the legal tradition of granting suspects and criminal defendants a right not to answer questions. In comparison, in our model the innocent defendant never gains from a right to silence.

Lang (2005) find that a Miranda Right to silence reduces wrongful confessions and convictions, at the price, however, of setting free criminals. Leshem (2008) show that a right to silence can help innocent suspects by providing them with a safer alternative to speech. Leshem assume that evidence may contradict an innocent suspect's true statement, though, guilty suspects are more likely to be contradicted by the evidence at trial. In both Lang (2005) and Leshem (2008) the suspect can make only one exculpatory statement. In our game it is crucial that the defendant can choose between two different exculpatory messages.

Mialon (2005) examine the effects of evidence disclosure requirements and the right to remain silent in a trial game. Mandatory pretrial disclosure by prosecutors reduces the conviction probability when there is also a right to silence. With or without mandatory disclosure a right to silence reduces the probability of both wrongful conviction and wrongful acquittal. Mialon assume that the suspect and the prosecutor cannot lie or claim something they cannot substantiate with evidence.

Other, less formal, justifications of the right to silence include preventing the abuse of public power and political tyranny (Stuntz 1993). Encouraging thorough and independent police investigation. Privacy and free will concerns (Gerstein 1970). There could also be reasons why an innocent choose silence and therefore there should be no adverse inference from silence (Dennis 1995 and Birch 1999).[6] Arguments against the right to silence goes back to Bentham (1825). The consequentialist view centers around Bentham's main claim: the only defendants who would avail themselves of, and benefit from, a right to silence are the guilty ones.

In a different vein, Glazer and Rubinstein (2004, 2006) consider an informed speaker who wishes to persuade an uninformed listener to take a certain action. The decision maker first chooses a rule that determines which speaker statements combined with some hard information are persuasive and lead to acceptance of the speaker's request. Glazer and Rubinstein study the properties of mechanisms that maximizes the probability that the listener accepts the request only when it is justified. They show that there always exist an optimal mechanism that is credible. In Glazer and Rubinstein (2006) the informed party decides which hard information to disclose whereas in Glazer and Rubinstein (2004) the decision maker decides which aspect of

[6] See generally Redmayne (2007) and Schwikkard (2009).

the relevant information to be verified. In our model a random experiment determines the realization of evidence and the speaker has no knowledge of this when making his statement.

3. A simple trial game

A *defendant* is accused of committing a crime and stand trial in front of a *judge*. There are three states of the world: s_{1I}, s_{2I}, and s_G. The defendant is guilty when the state is s_G and otherwise innocent. The non-degenerate state probabilities are p_{1I}, p_{2I}, and p_G. The prior probability of guilt is p_G and the probability of innocence is $1 - p_G$. We make the simplifying assumption that $p_{1I} = p_{2I} = (1 - p_G)/2$. The defendant knows the state while the judge only knows its distribution. The objective of the judge is to assess the true state and then choose a verdict accordingly. The defendant's objective is to convince the judge that he is innocent no matter what. The game we formulate falls into the category of *persuasion games*.

At the beginning of the trial a piece of hard evidence (e.g. forensics) is displayed in front of the court. The evidence rules out one of the two "innocent" states - we can think of the prosecutor disclosing her trial evidence. A more natural evidence structure would be to also take into account the possibility that the guilty state is ruled out. As the game is trivially solved in such instance we exclude this possibility without any loss of generality. Further, to keep it simple, when the defendant is guilty the two false "innocent" states are equally likely to be ruled out. If we interpret the hard evidence in isolation then nothing can be inferred in terms of the guilt/no-guilt question. The role of the evidence is simply to make an inference from the evidence in conjunction with a message from the defendant.

After the realization of evidence the defendant send one of two (cheap talk) messages from the set $M = \{m_1, m_2\}$. As far as the message signals a state (e.g. m_1 translates to claiming s_{1I}) the defendant incurs no physical or psychological costs from lying and we assume no risk of prosecution for perjury. We now describe the game and the timing in more detail.

Stage 1 (Judge's move). The judge chooses a decision rule (a strategy), σ_j. A decision rule assign a verdict (acquit/convict) to any possible combination of a state ruled out and a defendant message. For example, one contingency is [not s_{2I}, m_1] meaning that the evidence exclude s_{2I} and the defendant send m_1. We only consider deterministic decision rules i.e. the judge acquit with probability $P \in \{0,1\}$.

Stage 2 (The state). A state of the world is realized.

Stage 3 (Evidence realization). Hard evidence is disclosed and one false "innocent" state is ruled out. When the state is s_G then the two "innocent" states are equally likely to be ruled out. When s_{1I} (s_{2I}) is the true state then s_{2I} (s_{1I}) will be excluded by the evidence.

Stage 4 (Defendant's move). Before the defendant moves he observes the judge's decision rule and the state. Importantly, the defendant does not observe the evidence realization. A strategy for the defendant, σ_d, prescribes a message from M at any of the defendant's information sets. We allow for mixed strategies.

Stage 5 (Judgement). The defendant is acquitted or convicted as prescribed by the judge's decision rule.

Regardless of the state the defendant's payoff is 1 if he is acquitted and zero if he is convicted. The judge receives payoff zero if he acquits an innocent or convicts a criminal. If the judge convicts an innocent he receives payoff $-D$ and his payoff from acquitting a criminal is $-(1-D)$, where $D \in (0,1)$. Then D can be interpreted as the burden of proof or the weighting of the two type or errors.[7] Given a strategy pair (σ_j, σ_d), let Π_j and Π_d denote the judge and defendant's ex ante payoffs. The parties are risk neutral. The equilibrium notion is subgame perfect Nash.

In the way we have modeled the trial situation we have assumed that the

[7] The same representation of jury payoff is given in Seidmann (2005).

judge can pre-commit to his decision rule. We say that a judge rule is *credible* if there exist an optimal defendant strategy that induces ex post beliefs that makes it optimal for the judge to follow his decision rule.

4. Analysis

In this section we solve the game with emphasis on the equilibrium payoffs for varying values of p_G and D. There are four contingencies for which the judge must choose acquit or convict: [not s_{1I}, m_1], [not s_{2I}, m_1], [not s_{1I}, m_2], and [not s_{2I}, m_2]. Hence, there are 16 different decision rules. In table 1 we list the 16 alternatives. For example, if the judge choose σ_j^1 the defendant is acquitted independent of the evidence and the defendant's message.

	[not s_{1I}, m_1]	[not s_{2I}, m_1]	[not s_{1I}, m_2]	[not s_{2I}, m_2]
σ_j^1	Acquit	Acquit	Acquit	Acquit
σ_j^2	Acquit	Acquit	Acquit	Convict
σ_j^3	Acquit	Acquit	Convict	Acquit
σ_j^4	Acquit	Convict	Acquit	Acquit
σ_j^5	Convict	Acquit	Acquit	Acquit
σ_j^6	Acquit	Acquit	Convict	Convict
σ_j^7	Acquit	Convict	Acquit	Convict
σ_j^8	Acquit	Convict	Convict	Acquit
σ_j^9	Convict	Convict	Acquit	Acquit
σ_j^{10}	Convict	Acquit	Convict	Acquit
σ_j^{11}	Convict	Acquit	Acquit	Convict
σ_j^{12}	Convict	Convict	Convict	Convict
σ_j^{13}	Convict	Convict	Convict	Acquit
σ_j^{14}	Convict	Convict	Acquit	Convict
σ_j^{15}	Convict	Acquit	Convict	Convict
σ_j^{16}	Acquit	Convict	Convict	Convict

Table 1: Possible decision rules

In table 2 we propose a defendant strategy, σ_d^* (in proposition 1 we argue that σ_d^* dictates optimal behavior at any of the defendant's information sets). For example, given σ_j^1 and the state is s_{1I} then σ_d^* prescribes that the defendant send m_1. If the judge choose σ_j^{11} then σ_d^* dictates m_1 when the state is s_{1I}, m_2 when the state is s_{2I}, and equal randomization between m_1 and m_2 when the state is s_G.

	s_{1I}	s_{2I}	s_G
σ_j^1,σ_j^2, σ_j^3, σ_j^6,σ_j^7,σ_j^{10},σ_j^{12}, σ_j^{15},σ_j^{16}	m_1	m_1	m_1
σ_j^4, σ_j^5, σ_j^9, σ_j^{13}, σ_j^{14}	m_2	m_2	m_2
σ_j^8	m_2	m_1	$\frac{1}{2}m_1$, $\frac{1}{2}m_2$
σ_j^{11}	m_1	m_2	$\frac{1}{2}m_1$, $\frac{1}{2}m_2$

Table 2: Defendant strategy σ_d^*

Proposition 1:

1. When $D < \frac{p_G}{2-p_G}$; one equilibrium is $(\sigma_j^{12}, \sigma_d^*)$ and for any equilibrium we have $\Pi_j = -D(1-p_G)$ and $\Pi_d = 0$.

2. When $D \geq \frac{p_G}{2-p_G}$; one equilibrium is $(\sigma_j^{11}, \sigma_d^*)$ and for any equilibrium we have $\Pi_j = -\frac{1}{2}p_G(1-D)$ and $\Pi_d = 1 - \frac{1}{2}p_G$ (when $D = \frac{p_G}{2-p_G}$ we could also have $\Pi_d = 0$).

3. Given σ_d^* there always exist a credible equilibrium judge strategy.

Proof. We first show that σ_d^* is an equilibrium defendant strategy. Given any decision rule different from σ_j^8 and σ_j^{11} there exist a message that is optimal for the defendant independent of the state. It is straightforward to verify that σ_d^* is optimal in this respect. Suppose the judge choose σ_j^{11} and the state is s_G. In this case the defendant is indifferent between m_1 and m_2 and so equal randomization between m_1 and m_2 is also optimal. That is, if the defendant send m_1 he is acquitted (convicted) if s_{2I} (s_{1I}) is ruled out and if he send m_2 he is acquitted (convicted) if s_{1I} (s_{2I}) is ruled out. As s_{1I} and s_{2I} are equally likely to be ruled out the defendant is indifferent. Suppose the judge chooses σ_j^{11} and the state is s_{1I}. Here, the defendant is acquitted if he send m_1 while if he send m_2 he is convicted. Hence, m_1 is optimal. Opposite when the true state is s_{2I} it is optimal to send m_2. The parallel logic applies when arguing that σ_d^* is optimal given σ_j^8.

There are multiple equilibria. However, the judge's expected payoff is constant for any two equilibria. For any two equilibrium defendant strategies it must be that, conditional on the state, the chances of acquittal is the same whether the defendant play according to one or the other equilibrium strategy. Thus, any two equilibrium defendant strategies must give rise to the same expected judge payoff - whatever decision rule chosen by the judge. If we can identify one equilibrium we can characterize the judge's equilibrium payoff generally.

To find an equilibrium, given some p_G and D, we must compare the judge's expected payoff for the 16 different decision rules given that the defendant strategy is σ_d^*. Given σ_d^*, the judge's expected payoff following σ_j^1, σ_j^2, σ_j^3, σ_j^4, σ_j^5, σ_j^6, and σ_j^9 is $\Pi_j = -(1-D)p_G$ and $\Pi_d = 1$. For a decision rule like σ_j^1 the defendant can guarantee himself acquittal and the judge will acquit all criminals. As the defendant is guilty with probability p_G and the cost of acquitting a criminal is $-(1-D)$ we get that $\Pi_j = -(1-D)p_G$. For σ_j^{12} we have that all defendants are convicted and $\Pi_j = -D(1-p_G)$, $\Pi_d = 0$. This follows from the fact that the probability of innocence is $(1-p_G)$ and the cost of convicting an innocent is $-D$. For σ_j^7, σ_j^{10}, σ_j^{13}, σ_j^{14}, σ_j^{15}, and σ_j^{16} we get that $\Pi_j = -\frac{1}{2}D(1-p_G) - \frac{1}{2}(1-D)p_G$ and $\Pi_d = \frac{1}{2}$. For a strategy like σ_j^7 both the criminal and the innocent defendant is acquitted with probability $\frac{1}{2}$. For σ_j^8 and σ_j^{11} the payoffs are $\Pi_j = -\frac{1}{2}p_G(1-D)$ and $\Pi_d = 1 - \frac{1}{2}p_G$. For a decision rule like σ_j^{11} all innocent defendants are acquitted and criminals are convicted with probability $\frac{1}{2}$.

It is immediate that the judge payoff induced by σ_j^8 and σ_j^{11} is strictly higher, for any D and p_G, than all other decision rules except σ_j^{12}. Comparing the judge payoffs induced by σ_j^{11} and σ_j^{12} we get that σ_j^{11} is strictly optimal if and only if: $-\frac{1}{2}p_G(1-D) > -D(1-p_G)$. Simplified, σ_j^{11} is strictly optimal if and only if: $D > \frac{p_G}{2-p_G}$. Thus, when $D > \frac{p_G}{2-p_G}$ one equilibrium is $(\sigma_j^{11}, \sigma_d^*)$ and for any equilibrium we have $\Pi_j = -\frac{1}{2}p_G(1-D)$ and $\Pi_d = 1 - \frac{1}{2}p_G$.

When $D < \frac{p_G}{2-p_G}$ one equilibrium is $(\sigma_j^{12}, \sigma_d^*)$ and for any equilibrium $\Pi_j = -D(1-p_G)$ and $\Pi_d = 0$. In the case $D = \frac{p_G}{2-p_G}$ one equilibrium is $(\sigma_j^{11}, \sigma_d^*)$ and for any equilibrium $\Pi_j = -\frac{1}{2}p_G(1-D)$ and $\Pi_d = 1 - \frac{1}{2}p_G$ or $\Pi_d = 0$. This proves proposition 1.1 and 1.2.

Consider the equilibrium $(\sigma_j^{12}, \sigma_d^*)$ when $D < \frac{p_G}{2-p_G}$. Here the defendant always send m_1 and nothing can be inferred from this ex post, which makes σ_j^{12} credible. Consider the equilibrium $(\sigma_j^{11}, \sigma_d^*)$ when $D \geq \frac{p_G}{2-p_G}$. All innocent defendants are acquitted in equilibrium. Suppose instead the state is s_G. By σ_d^* we know that the defendant send m_1 and m_2 with probability $\frac{1}{2}$. Moreover, when the defendant send m_1 (m_2) and s_{1I} (s_{2I}) is ruled out he is rightfully convicted (ex post optimality). The conditional probability that the state is s_G given that m_1 is sent and s_{2I} is ruled out is (using Bayes' theorem: $P(A|B) = \frac{P(B|A)P(A)}{P(B)}$): $p(s_G \mid [m_1, \textit{not } s_{2I}]) = \frac{0.25p_G}{0.5(1-p_G)+0.25p_G} = \frac{p_G}{2-p_G}$. We know that $D \geq \frac{p_G}{2-p_G}$ and thereby it is optimal for the judge to follow his decision rule and acquit. Hence, σ_j^{11} is credible proving proposition 1.3 □

The two judge strategies σ_j^8 and σ_j^{11} stand out in one important respect. For any other decision rule the defendant's best reply does not strictly depend on the state and the judge could generate the same expected payoffs in a game that leaves the defendant with no chance to speak. This is not the case for σ_j^8 or σ_j^{11} where the defendant optimally shift from sending one message when the state is s_{1I} to the other message when the state is s_{2I}. In turn, and in combination with the evidence, this can help the judge lowering the probability of miscarriages of justice. Given σ_j^{11}, when the state is s_{1I} the defendant can send m_1 and be sure of acquittal (surely when the state is s_{1I} then s_{2I} is ruled out by evidence). If instead the defendant send m_2 he is convicted. Obviously m_1 is optimal. When the state is s_{2I} the defendant can send m_2 and be acquitted and avoid conviction which would be the consequence of m_1. When the state is s_G there is no way to tell whether s_{1I} or s_{2I} will be ruled out and the defendant is convicted with probability $\frac{1}{2}$ following either m_1 or m_2. When the defendant's message is inconsistent with the evidence the judge may, correctly, draw a negative inference.[8] [9] In this way, given optimal defendant behavior (following e.g. σ_d^*) innocent defendants are acquitted and criminals are acquitted with probability $\frac{1}{2}$.

Given σ_d^*, for any of the decision rules other than σ_j^8 and σ_j^{11} we will get either acquittal of all defendants, conviction of all defendants, or both innocent and guilty defendants will be acquitted with probability $\frac{1}{2}$. It follows that σ_j^{11} induces a strictly higher judge payoff when the alternative is acquitting all defendants or convicting all defendants with probability $\frac{1}{2}$. The relevant question becomes whether the judge should convict all defendants (σ_j^{12}) or follow a decision rule like σ_j^{11} where innocent defendants are acquitted and criminals are convicted with probability $\frac{1}{2}$. When $D > \frac{p_G}{2-p_G}$ the cost of convicting an innocent (D) is sufficiently high relative to the prior probability of guilt that the judge payoff is higher, given optimal defendant behavior, following either σ_j^8 or σ_j^{11} than the decision rule σ_j^{12}. Opposite when $D < \frac{p_G}{2-p_G}$, and it pays to convict all defendants.

The proof of Proposition 1.3 verifies that our assumption that the judge can commit to his decision rule is not crucial for the results. However, it is an open question whether ex post optimality would hold in a more general setting.

Confession premium: It is indisputable that most suspects confess or plead guilty and few cases go all the way to trial.[10] A suspect who confess early is likely to receive a lessor sentence and there can also be psychological gains from confession like ridding oneself of a feeling of remorse. These benefits may very well seem more attractive than a small chance of acquittal following a long trial. How would the results of proposition 1 change if we include a premium for confession? Suppose we add a third message "confess"

[8] It is common practice for the prosecutor (or plaintiff) to try to undermine the credibility of the defendant's trial testimony by proving inconsistencies. In Great American v. Lowry LLC (2007) the plaintiff obtained an affidavit from a technician working for the defendant that contradicted the defendant's testimony. On these grounds the court reduced Great American's burden of proof to a preponderance of the evidence.

[9] In our model it is not possible to fabricate false evidence.

[10] About 6% of felony defendants go to trial and 66% plead guilty, see U.S. Dep't of Justice, Bureau of Justice Statistics, Sourcebook of Criminal Justice Statistics (1999).

so that any defendant who at the beginning of the game confess is immediately convicted (confession case) and he receives a compensation equal to $x \in (0,1)$. Thus, a defendant who confess receives a certain payoff equal to x. The judge is unaffected by x. When $D < \frac{p_G}{2-p_G}$ a premium for confessing implies that all defendants confess - also innocent defendants. This must be true as if the defendant does not confess we know by proposition 1 that all defendants are convicted in equilibrium.

When $D > \frac{p_G}{2-p_G}$ a confession premium would never let the innocent defendant to make a false confession as he is otherwise guaranteed acquittal in equilibrium, see proposition 1. If $x < \frac{1}{2}$ then neither would criminals choose to confess as they are better off lying and hoping not to be contradicted by the evidence. Thus, everyone is unaffected by the confession premium. However, if the confession premium is substantial, $x > \frac{1}{2}$, then criminals will confess without a trial and the judge and the guilty defendant are strictly better off. The judge obtains maximum payoff as all criminals are convicted, though they receive a premium, and innocent defendants are acquitted following a trial.

4.1 The right to remain silent

Most Common law countries grant criminal suspects a "right to silence". The U. S. Fifth Amendment's privilege against self-incrimination implies that a suspect can refuse to give any statements at the police interrogation stage or at his/her own trial. Moreover, in *Miranda v. Arizona* (1966) the Supreme Court held that the Fifth Amendment right to silence would be violated were the jury to draw an adverse inference from silence. Since *Carter v. Kentucky* (1981)[11] the judge must also instruct the jury not to make any inference from a defendant's silence. In Canada the courts have held that drawing an adverse inference from silence is unconstitutional. Another variation of the right to silence exist in England. Following the Criminal Justice and Public Order act 1994, the court is allowed to draw an adverse inference from both

[11] *Carter v. Kentucky*, 450 U.S. 288 (1981).

pretrial and trial silence. However, the difference between the American and English system is less stark if one takes into account that American juries may not always respect the instruction not to draw any inference from a defendant's refusal to testify.

In this section we consider the implications of an American right to silence in our model. We add an extra "silence" message to the defendant's stage 4 messages ($M = \{m_1, m_2, "silent"\}$). When the defendant send the "silent" message the verdict must be conditioned only on hard evidence and prior probability of guilt - as if the defendant was not given the chance to speak. In our model the trial evidence is neutral in the sense that, when interpreted in isolation, it does not say anything about the probability of guilt. Thus, when the defendant is silent he *must* be acquitted if $p_G < D$.[12] On the other hand, when $p_G \geq D$ the defendant *must* be convicted after "silence". We simply constraint the judge's set of decision rules as we dictate what must be the verdict in the case the defendant is silent. The results are stated in comparison to the results of the previous section with no confession premium.

Proposition 2:

1. When $p_G < D$; the judge's equilibrium payoff decreases with a right to silence.

2. When $p_G < D$; the innocent defendant is indifferent while the criminal gains from a right to silence.

3. When $p_G \geq D$; the parties equilibrium payoffs are unaffected by a right to silence.

Proof. When $p_G < D$ the defendant can send the silent message and be acquittal for sure no matter which decision rule the judge chooses. Hence, it is clear that in any equilibrium, when $p_G < D$, necessarily all defendants are acquitted. This gives a judge payoff equal to $-p_G(1 - D)$. Without a right to silence the judge's payoff, when $p_G < D$, is $-\frac{1}{2}p_G(1 - D)$ (see proposition

[12] A similar representation of a silent message is given in Seidmann (2005).

1). It follows that the judge is strictly worse off from the defendant's right to silence. Without a right to silence all innocent defendants were acquitted and criminals were convicted with probability $\frac{1}{2}$. Hence, when $p_G < D$, it is the criminal who gains from a right to silence and the innocent defendant is equal off. When $p_G \geq D$ the judge must convict after a silent message. It is without loss of generality to assume that the defendant never send the silent message and we are left with the same situation as before the introduction of a right to silence. Thus, the equilibrium payoffs follows from proposition 1 and everyone is unaffected by the right to silence $\square$

The problem with a right to silence becomes apparent when the prior probability of guilt is low enough, and the standard of proof sufficiently high, that the criminal can remain silent and be sure of acquitted. In such case, without the right, defendants with solid non-incriminating testimonies are acquitted whereas criminals who's statements are contradicted by the trial evidence are convicted (see proposition 1). Hence, in our model innocent defendants are unaffected by the right while criminals benefit. When $p_G \geq D$ the prior evidence against a silent defendant is strong enough for conviction without any inference from silence and the judge must convict after silence. In this case the "silent" message is redundant.

The empirical evidence suggest that the condition $p_G < D$ is satisfied in most criminal trials. As already mentioned around 1% of felony defendants are acquitted after trial! The progress in forensic sciences and pressure on police and prosecution to make the cases as "bulletproof" as possible, or else drop charges, makes prior probability of guilt in criminal trials very high. If so, our model says that rational guilty defendants should either lie and make an exculpatory testimony or confess and enjoy the immediate benefits from that. In this respect Cassell and Hayman (1996) find that between 10% and 20% of suspects waives the right to silence at the interrogation stage.

Matters are different in lawsuits. Here, the prior probability that a complaint is justified is often close to a fifty-fifty assertion. Or, a good guess of the actual damages caused by the defendant upon the plaintiff is somehow half way between what the plaintiff claims and what the defendant claims.

Hence, in respect to proposition 2, an American right to silence would be a powerful tool for a guilty defendant in civil suits. However, and perhaps therefore, in all Anglo-Saxon countries the judge or arbitrator in lawsuits are free to make an adverse inference from a party's silence.

Leo (2001) studies the effects of "no adverse inference from silence" following the Miranda case in 1966. Leo find confession and conviction rates slightly decreased following Miranda and thereafter the effects vanished. Evidence from a study conducted following the permission to draw adverse inference from silence in England in (1994) shows that the change had an effect, though minor. If guilty defendants rationally used the right and opted for silence instead of risky lies or sure conviction after confession, then it is anticipated that the Criminal Justice act in 1994 should decrease the silence rate. Bucke, Street and Brown (2000) find that 10% of interrogated suspects used the right to silence before 1994 while 6% did not answer any questions after 1994. Further, 13% did not answer some questions when interrogated before 1994 and 10% did not answer some questions after the adverse inference was permissible.

4.2 Mandatory pretrial disclosure

The U.S. Fifth Amendment's right to due process of law require the prosecutor to share evidence with the defendant before the trial begin. Evidence include documents, data, objects, witnesses and so forth.[13] [14] In this section we evaluate how prior knowledge of trial evidence influence the parties payoffs. In our game this implies that the defendant observes the evidence realization before the message sending at stage 4. With this modification the

[13]Also in U.S. civil procedure there are rules requiring the parties to a lawsuit to disclose information about whatever evidence they intend to present. See Federal Rules of Civil Procedure rule 26(a).

[14]We should mention that pretrial disclosure does not preclude the use of discovery where the defendant can request the prosecutor to disclose evidence that is favorable to the defendant and may not otherwise reach the court. In the model we have not taken into account that a strategic career pursuing prosecutor may suppress evidence favorable to the defendant.

criminal can contingent his message on whether s_{1I} or s_{2I} has been excluded by the evidence. The results are stated in comparison to proposition 1. Consider the defendant strategy σ_d^{**} in table 3 below. For example, given that the judge choose σ_j^8, the state is s_G, and the evidence rule out s_{1I}, then σ_d^{**} prescribes the message m_1. We propose that σ_d^{**} is optimal given any judge move. The question then becomes, given σ_d^{**}, what is an optimal decision rule for varying values of p_G and D.

	s_{1I}, not s_{2I}	s_{2I}, not s_{1I}	s_G, not s_{1I}	s_G, not s_{2I}
σ_j^1,σ_j^2, σ_j^3, σ_j^6, σ_j^7	m_1	m_1	m_1	m_1
σ_j^{10},σ_j^{12},σ_j^{15},σ_j^{16}	m_1	m_1	m_1	m_1
σ_j^4,σ_j^5,σ_j^9,σ_j^{13},σ_j^{14}	m_2	m_2	m_2	m_2
σ_j^8	m_2	m_1	m_1	m_2
σ_j^{11}	m_1	m_2	m_2	m_1

Table 3: Defendant strategy σ_d^{**}.

Proposition 3:

1. When $D \leq \frac{p_G}{2-p_G}$; the judge is unaffected by pretrial disclosure.

2. When $D > \frac{p_G}{2-p_G}$; the judge's equilibrium payoff decreases following mandatory pretrial disclosure.

3. When $p_G > D > \frac{p_G}{2-p_G}$; both the innocent defendant and the criminal loses from pretrial disclosure.

4. When $D > p_G$; the criminal gains from pretrial disclosure while the innocent defendant is indifferent.

5. When $D = p_G$; the effects of pretrial disclosure on the innocent and the criminal defendant are indeterminate.

6. With pretrial disclosure equilibrium payoffs are unaffected by the introduction of a right to silence.

Proof. It is immediate that σ_d^{**} is an optimal defendant strategy: For σ_j^1, σ_j^2, σ_j^3, and σ_j^6 the defendant can obtain maximum payoff by sending m_1 independent of the state and the evidence. In the same way, given σ_j^4, σ_j^5 and σ_j^9 the defendant can send m_2 and be sure of acquittal. For σ_j^{12} the defendant is convicted no matter what. For σ_j^7 the defendant is convicted whenever s_{2I} is ruled out and he is acquitted whenever s_{1I} is ruled out so claiming m_1 is also optimal. Similarly with σ_j^{10}. For σ_j^{13} and σ_j^{14} the only chance of acquittal is for the defendant to send m_2. For σ_j^{15} and σ_j^{16} the defendant's only chance for acquittal is by sending m_1. Consider σ_j^{11}; when the state is s_G and s_{1I} has been excluded it is optimal to send m_2 and when the state is s_G and s_{2I} is ruled out it is optimal to send m_1. When the state is s_{1I} it is optimal to send m_1 while it is optimal to send m_2 when the state is s_{2I}. The parallel reasoning applies to σ_j^8.

Given σ_d^{**}, the judge's expected payoff following σ_j^1, σ_j^2, σ_j^3, σ_j^4, σ_j^5, σ_j^6, σ_j^8, σ_j^9, and σ_j^{11} is $\Pi_j = -(1-D)p_G$ and $\Pi_d = 1$. For σ_j^{12} we have $\Pi_j = -D(1-p_G)$ and $\Pi_d = 0$. For σ_j^7, σ_j^{10}, σ_j^{13}, σ_j^{14}, σ_j^{15}, and σ_j^{16} we have $\Pi_j = -\frac{1}{2}D(1-p_G) - \frac{1}{2}(1-D)p_G$ and $\Pi_d = \frac{1}{2}$. Comparing the judge payoff from a strategy like σ_j^1 with the payoff from σ_j^{12} or σ_j^7 we get that σ_j^1 induces a strictly higher judge payoff when; $-p_G(1-D) > -D(1-p_G)$, or simplified, when $D > p_G$. When $D < p_G$ then σ_j^{12} induces a strictly higher payoff and $(\sigma_j^{12}, \sigma_d^{**})$ is an equilibrium. When $D = p_G$ any judge strategy constitutes an equilibrium together with σ_d^{**}.

When $D \leq \frac{p_G}{2-p_G}$ the equilibrium decision rule is σ_j^{12} and the equilibrium judge payoff is $\Pi_j = -D(1-p_G)$, which is the same as in equilibrium absent of pretrial disclosure and hence the judge is unaffected. This proves proposition 3.1. Suppose $D > \frac{p_G}{2-p_G}$. When $D \geq p_G$ the equilibrium judge payoff is $\Pi_j = -(1-D)p_G$. Without pretrial disclosure the judge's payoff is $\Pi_j = -\frac{1}{2}p_G(1-D)$ (see proposition 1) which is strictly higher. When $D < p_G$ the judge's equilibrium payoff is $\Pi_j = -D(1-p_G)$ which is lower than his equilibrium payoff without initial disclosure ($\Pi_j = -\frac{1}{2}p_G(1-D)$) when

$D > \frac{p_G}{2-p_G}$. This proves proposition 3.2.

When $p_G > D > \frac{p_G}{2-p_G}$ the equilibrium defendant payoff is zero (following σ_j^{12}) while in the situation without pretrial disclosure it is $1 - \frac{1}{2}p_G$ (see proposition 1). Without initial disclosure, the innocent is always acquitted and the criminal is acquitted with probability $\frac{1}{2}$. Hence, both the criminal and the innocent loses from pretrial disclosure when $p_G > D > \frac{p_G}{2-p_G}$. This proves proposition 3.3. When $D > p_G$ the equilibrium strategy is like σ_j^1 and all defendants are acquitted. Without pretrial disclosure, and $D > p_G$, the innocent is acquitted and the criminal is acquitted with probability $\frac{1}{2}$. Hence, the criminal gains while the innocent is equal off, proving proposition 3.4. When $D = p_G$ it is clear that the effects on the criminal and the innocent are indeterminate.

If pretrial disclosure is already in effect then a right to silence does not alter any of the results: When $D > p_G$ all defendants are acquitted in equilibrium and a "silent" message would not make a difference. When $D \leq p_G$ the defendant must be convicted after being silent and the possibility to send a "silent" message clearly does not alter any of the results $\square$

We find that there are harmful effects of pretrial disclosure. Once the criminal can act conditionally on the evidence the judge cannot make any negative (or positive) inference from the defendant's statement in conjunction with the evidence. Without pretrial disclosure, the judge makes a valuable inference from the defendant's statement when $D > \frac{p_G}{2-p_G}$ and all innocent defendants are acquitted and criminals are convicted with probability one half. With initial disclosure it becomes optimal to convict all defendants when $p_G > D$ and acquit all defendants when $D > p_G$. Thus, when $p_G > D > \frac{p_G}{2-p_G}$ both the criminal and the innocent loses, especially the innocent defendant is worse off as he goes from sure acquittal to sure conviction. This last point provide a rationale for why rebuttal evidence (prosecutor's evidence that specifically relates to the defendant's testimony) is exempted from pretrial disclosure; as we have seen this may actually help innocent defendants.[15] When $D > p_G$ all defendants are acquitted thereby favor-

[15] Fed. R. Crim. P. 16(a). On this issue see also Seidmann and Stein (2000).

ing criminals who would otherwise face conviction with probability $1/2$ (see proposition 1). Here, the innocent is indifferent as he would be acquitted also without pretrial disclosure.

The effects of pretrial disclosure would disappear had we instead focused on the suspect's statement at the police interrogation stage. At this point a suspect has little knowledge about the amount and type of inculpatory evidence collected. However, (i) police interviews may be conducted long after charges are filed, (ii) suspects can choose to change their initial statements, or (iii) suspects can remain silent when interrogated and later take the stand at trial. In these cases guilty suspects can still make strategic use of the information about the opponents plan for evidence disclosure following disclosure requirements. In other situations we can think of the same type of strategic behavior used by career seeking prosecutors and unjustified plaintiffs.

As long as the parties are subject to pretrial disclosure the judge is unaffected by a right to silence. With mandatory disclosure the judge cannot make any inference from the defendant's statement in equilibrium and all defendants are acquitted when $D > p_G$. This makes a "silent" where defendants must be acquitted whenever $D > p_G$ redundant.

What if the innocent defendant only knows that he is not guilty? While it is reasonable to assume that a guilty defendant perfectly knows the true state (all relevant aspects surrounding the crime and the scene of the crime) in many cases it is unlikely that an innocent defendant knows more about the accusations except the fact that he is innocent. Suppose the innocent defendant only knows that with equal probability one of s_{1I} and s_{2I} has occurred. In this case the defendant cannot choose different messages depending on whether the state is s_{1I} or s_{2I}. As a consequence, like in the previous section with initial disclosure, the judge cannot infer anything from the messages in equilibrium and listening to the defendant does not make a (game theoretic) difference. This leads us to the exact same conclusions as in proposition 3. Notice that, given the decision rules σ_j^8 and σ_j^{11} the innocent defendant is indifferent between m_1 and m_2, as he is convicted with probability $\frac{1}{2}$ in any case.

As with pretrial disclosure, the innocent defendant's lack of information implies that a right to silence has no impact on the choice of optimal decision rules and the expected payoffs. This is not surprising as it was the innocent defendant's knowledge of the state that allows the judge to make any positive/negative inference from non-disproven/disproven statements.

5. Conclusion

We have studied a simple trial game in which the judge initially commit to a decision rule before a piece of evidence is realized and the defendant makes a statement. In equilibrium, the judge may put weight on the defendant's cheap talk message when interpreted in combination with the evidence. While the innocent defendant can always make an irrefutable exculpatory statement (a true statement) this is not the case for the criminal who risk making an inconsistent statement. It is not surprising that, when introducing a right to silence, the judge is not strictly better off as this restricts his decision power in some instances when the defendant refuses to speak. Neither is it surprising that under some conditions the judge is worse off with a right to silence. This happens when the ex ante probability of guilt is low enough that the defendant must be set free following silence. This finding can explain why in most Common law countries the rule against adverse inference from silence does not apply to civil actions where the prior evidence against the defendant is typically much weaker than in e.g. felony trials. We have also showed that the effects of a right to silence cancels out if the defendant fully knows about the prosecutors trial evidence before he testifies and/or if the non-guilty defendant knows nothing more about the alleged crime than the fact that he is innocent. When looking at the effects of initial disclosure of trial evidence in isolation we find that the judge is never better off, however, under some conditions the criminal is actually strictly worse off.

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The controlling founder, non-controlling ownership blocks, and liquidity traders

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Abstract

We analyze the situation of a founder going public and retaining the controlling ownership block and CEO position in an environment with poor legal investor protection. We propose that ex ante signaling of less expropriation of outside shareholders may *not* be purely beneficial to the founder. In our model, potential investors are willing to pay a share price above the share's intrinsic value. This is because board members, through non-controlling ownership blocks, can absorb private information about the expropriation level. We assume non-controlling shareholders can trade anonymously and the board member who first absorb the private information trade with liquidity traders through a specialist setting a bid-ask spread to earn zero expected profits. The founder optimally choose projects with high variance of private benefits in order to maximize the premium board members are willing to pay for the private information. When greater uncertainty about the expropriation comes along with projects involving higher expected private benefits there will be more expropriation of outside shareholders.

1. Introduction

Recent research has shown that most firms in the world are family controlled see among others La Porta et al. (2000) and Faccio and Lang (2002) and in countries characterized by poor legal investor protection about one half of the public listed family firms are also managed by a family member. In parallel studies it has been documented that private benefits (benefits disproportional accruing to the party in control) are significant and may account for more than 50% of the value of the firm, see Nenova (2000) and Dyck and Zingales (2004). Private benefits can take the form of: above market salaries to members of the controlling family, transfer pricing, subsidized personal loans, non-arms-length asset transactions, moving high growth opportunities within the company to a personally owned firm and in some cases outright theft (Johnson et al 2000)). By its very nature, private benefits are difficult to observe and quantify and they are non verifiable (i.e. not provable in court). It has been empirically established, mostly due to the work of La Porta et al, that high private benefits go together with family control and follow countries with intermediary or poor legal investor protection. The main theoretical reason for this phenomenon has been provided by Bebchuk (1999). When legal investor protection is poor the resulting high potential for private benefits renders dispersed ownership unstable i.e. an acquirer could reap the private benefits from buying the controlling ownership stake. However, concentrated ownership is stable, since an acquirer would have to compensate the controlling family from any losses of private benefits.

Is family control and private benefits extraction necessarily a problem? The literature on this is large. Mostly it points to negative externalities from the expropriation of outside shareholders causing underdeveloped financial markets: Less valuable stock markets and fewer listed firms (La Porta et al. 1997), higher valuation of listed firms relative to their assets (Claessens et al. 2002; La Porta et al. 2002) and lower dividend payouts (La Porta et al. 2000). Morck, Stangeland and Yeung (2000) link the dominance of few powerful corporate families with economic entrenchment. On the other hand, concentrated ownership provides a positive externality as the controlling family has incentives to monitor the management, see Jensen and Meckling (1976) and Morck et al. (1988).

More interestingly, in the context of this paper, is that there are costs from the private benefit extraction that are borne by the controlling family. First, when private benefits are high, the family may find it difficult to raise enough external funds to finance profitable projects. Since investors anticipates being expropriated the cost of capital increases. Secondly, it seems very intuitive that there are costs from expropriation as the resources extracted have a higher value within the firm than to the family. If the investors have rational expectations, the costs from expropriation are borne by the controlling family. These issues raises an obvious question; why do the controlling family expropriate non-controlling shareholders? The answer is that there is a contractual and moral hazard problem; investors place their money ex ante and the controlling family decides on private benefit extraction ex post. From this it follows that if the controlling family could constraint themselves, ex ante, to little expropriation, it would do so. In this respect one could think of corporate charters, long-term transparency installments, binding board and ownership structures and cross listings in countries with better investor protection of outside shareholders as remedies to limit the diversion.

This paper challenges the notion that if the controlling family can, ex ante, credibly signal less expropriation of non-controlling shareholders, it is purely beneficial. We argue that, once the founder family has complete control over ownership and management, the monitoring role of the board is minimal. In such a setting a large but non-controlling shareholder being represented at the company board will have little influence on corporate decisions. If a board member opposes the diversion of resources by the controlling family, a poor legal environment renders the board member few means of stopping this conduct or compensation in the case it is detected. Instead we may think of the corporate board as a place where significant but non-controlling shareholders elect board members in order to get private information about the level of private benefit extraction. This kind of information could be valuable for several reasons e.g. if the board member is already an active player in the business environment. However, we limit ourselves to the case where the private information is solely used for speculation in the firms shares.

A controlling founder can take actions that benefit himself but harm the non-controlling shareholders. One example is non-arms length transactions with related parties. Initially one can only guess about the occurrence and significance of such actions. Being close to the founder, as a board member, allows one to get private information about the actual potential for private benefits. The greater asymmetry between the knowledge of the non-controlling board member and the expectations of the general public, the more valuable is the private information to the board member in terms of speculation in shares. The information is even more valuable if the non-controlling board member, apart from the founder, has exclusive access to this insight. We propose that the founder may, initially, be encouraged to choose an observable firm strategy that involves high expected expropriation and high uncertainty about the level of private benefits, as he collects any premium paid for non-controlling ownership blocks that allows for the election of board members.

The private information is valuable for speculation only if board members can trade on it. We apply the trading mechanism of Benveniste et al. (1992) for a passive specialist and anonymous trade. The board member who first absorb the private information can trade with uninformed liquidity traders, through a specialist setting a bid-ask spread to earn zero expected profits. Following the framework of Glosten and Milgrom (1985) the specialist offset the expected losses from informed traders with gains from liquidity traders.

A number of studies has modeled the expropriation of non-controlling shareholders by the controlling owner. Related to present paper is Bennedsen and Wolfenzon (2000) who analyze the role of large but non-controlling owners. They find that, initially, the founder has an incentive to dilute control and choose an ownership structure with several large shareholders, to reduce the costly private benefit diversion. Pagano and Roell (1998) model the founders going public decision in terms of balancing the productive monitoring by significant shareholders, in the sense that it constraints the founder from private benefit extraction and disturbing overmonitoring. Burkart, Panunzi and Shleifer (2003) study the agency costs and tradeoff between joint and separated ownership and management. The agency costs are increasing as the legal investor protection of outside shareholders weakens. In Burkart, Gromb and Panunzi (1997) ownership and management is separated. They find that ex ante reduction of managerial private benefits and discretion also comes with costs since it reduces managerial initiative that otherwise could contribute to firm value.

The contribution of this paper is to consider the level of expropriation as uncertain and the role of the board member, elected by a non-controlling ownership block, as absorbing private information rather than monitoring the controlling founder. The novel finding is that before going public the founder's welfare may be increasing in the potential for private benefits - an increase at the expense of liquidity traders. This raises an interesting concern in terms of policy implications and how to curb private benefits and limit the negative externality from expropriation of outsiders. One line of argument has been to stimulate the business environment to accommodate firm commitments to little expropriation, one example is the development of voluntary corporate governance code of conducts. Another path has been to improve the quality of legal statutory and institutional investor protection. Our findings highlights the importance of external investor protection in the sense of improved institutional and statutory protection.

Our analysis has testable empirical implications. We predict that in countries with intermediary to poor legal investor protection, large but non-controlling ownership blocks sell at a premium. More precisely, a premium in firms where the founder or her descendants have complete control over ownership and management and the monitoring incentives are minimal. The model also predict that the premium is decreasing in the number of distinct non-controlling ownership blocks that allow for the election of a board member. Our conjectures is in contrast to the idea of large non-controlling shareholders serving as monitoring the controlling family. As the non-controlling ownership block incurs monitoring cost and share the gains with all the non-controlling shareholders, the block should sell at a discount and not a premium.

The empirical evidence on these issues is very sparse as most studies focus exclusively on the controlling ownership block. To our knowledge the only evidence comes from Dyck and Zingales (2004). They find that the premium paid for ownership blocks above 20% does not decrease when there already exist a shareholder with a stake in excess of 20%. This result does not support the monitoring motive. However, it is difficult to infer much from the Dyck and Zingales finding as the premium paid for ownership blocks reflect more than monitoring costs or expected gains from trading on private information e.g. there could be a sharing of control and private benefits or the chance that one of the blocks turn into the sole controlling block. To precisely test the mechanisms presented in this paper a closer look at the relation between the controlling family, board composition, ownership structure and trading patterns is needed.

2. The Model

Consider a firm, initially fully owned and managed by its founder, going public. The timeline of the model is shown in Figure 1. At date 0, a fraction (1 - α) of the J outstanding shares are sold to non-controlling shareholders. The controlling fraction α is retained by the wealth constrained founder. α is given and is the minimum fraction of shares that ensures the founder complete control of the firm. All shareholders are risk-neutral. The controlling owner and the manager have perfect congruent objectives (it could be the same person). Cash flow rights and voting rights are proportional i.e. 1 % of the cash flow rights provides 1 % of the voting rights. Let c_n denote each non-controlling shareholder's fraction of total shares such that $\sum_{n=1}^{N} c_n =$ (1 - α), $n = 1.....N$.

t=0	t=1	t=2	t=3
Founder chooses project, sells 1 - α shares. Information blocks are formed. Specialist buys inventory.	Founder knows b. One information block gets informed about b.	Liquidity trade. Informed block trade on asymmetric info. After trade disclosure.	Dividends and private benefits are realized.

Figure 1. Timing of the model.

At date 0, the founder decides on which of two projects {A, B} to undertake. The verifiable revenue v involved in the two projects is the same and constant. However, the potential for non-verifiable private benefits of control, b, is uncertain and differ between the two projects. If project A is chosen the firm will generate revenue v and with equal probability the potential for private benefits will be b_{High} or zero. If project B is chosen the firm will generate revenue v and with equal probability the private benefits will be b_{Low} or zero. Project A has higher variance of private benefits and also higher expected private benefit extraction. In this respect one can consider project B as a way for the founder to, ex ante, signal little expropriation of outside shareholders. The two projects payoffs are shown in table 1. At date 0, all shareholders observe which project the founder chooses. The shareholders know the payoff and probability distribution for both projects. Private benefits are resources extracted from the firm by the controlling founder, at the expense of all shareholders (controlling and non-controlling). We assume no efficiency loss from expropriation.

Probability	Project A	Project B
1/2	$\{v, b_{High}\}$	$\{v, b_{Low}\}$
1/2	$\{v, 0\}$	$\{v, 0\}$

Table 1: *Payoffs from projects.* $v > b_{High} > b_{Low} > 0$.

At date zero when all investors share the same information we assign an initial intrinsic value to the share. Let p^* be the initial intrinsic value of a share to the non-controlling shareholders (this is a weighted average of the case of positive and zero private benefits). $p_i^* = \frac{1}{J}[\frac{1}{2}v + \frac{1}{2}(v - b_i)]$ where $i = A, B$. At date 1, when one of the two states has occurred (zero or positive private benefits), the revised intrinsic value is $\frac{1}{J}v$ or $\frac{1}{J}(v - b_i)$. Let ρ_i (where $i = A, B$) be the absolute difference between the initial and the date 1 intrinsic value. If it turns out that there are zero private benefits $\rho_i = |\frac{1}{J}[\frac{1}{2}v + \frac{1}{2}(v - b_i)] - \frac{1}{J}v| = \frac{b_i}{2J}$. In case of positive private benefits $\rho_i = |\frac{1}{J}[\frac{1}{2}v + \frac{1}{2}(v - b_i)] - \frac{1}{J}(v - b_i)| = \frac{b_i}{2J}$. Note that $\rho_A > \rho_B$. To lighten notation we suppress the subscript for the project chosen in what follows.

Simultaneous with the initial selling of shares, non-controlling shareholders can form *information blocks* at a fixed cost M, in order to get informed about the level of private benefits. The fixed cost M could be interpreted as a cost of effort from learning about the private benefits. Establishing an information block, c_n^{ib}, requires that the shareholder buys a certain minimum fraction of the shares γ which ensures her a seat at the company board. Let $\gamma < (1 - \alpha)$. At the initial selling, the part of the shares not retained by the founder or sold to block holders, is held as inventory by a specialist (or market maker) to facilitate liquidity.

At date 1, the founder gets to know about the actual potential for private benefits. At the same time *one* of the information blocks receives a signal that reveals the level of private benefits. This could be interpreted as the one information block that absorbs the signal first. Assume that the probability that information block c_n^{ib} gets informed is $\frac{1}{\#c_n^{ib}}$.

At date 2, immediately after an information block has received private information about the level of private benefits, trade takes place. We consider a trading mechanism with heterogeneously informed traders, which is the same as Benveniste et al. (1992) for the special case of a passive specialist and one round of trade. In their model all trade is anonymous and goes through the specialist. Investors place limit orders at the specialist who is unable to exercise any discretion in the execution of orders. The specialist sets a bid-ask spread to earn zero expected profits. All investors within the round of trade are batched and cannot observe and learn from each others market orders. Investors are constrained by an aggregate position limit (short or long) equal to g shares. By this we rule out infinite security demands by the informed traders. The interest rate is zero.

There are three types of investors involved in trade at date 2: the specialist, liquidity traders and the information block. The information block(s) that did not receive the signal does not have any liquidity purposes and therefore does not take part in trade. The founder does not trade. We assume he is wealth constrained from any long positions and any selling of shares will render control contestable. When control is contestable, a buyer can size up a controlling ownership block and reap the private benefits without compensating the founder for the loss of private benefits. At the beginning of trading only the owner of the information block knows the actual level of private benefits and at the end of the trading round there is after-trade disclosure and the amount of diversion becomes common knowledge i.e. investors make perfect inference from the trading disclosure.

The role of the specialist is to set a bid-ask spread to facilitate trade in a market with informed (information block) and uninformed (liquidity traders) investors. Following the framework of Glosten and Milgrom (1985) the specialist sets a bid-ask spread in order to offset expected losses from trade with informed shareholders by gains from liquidity traders. Through competition or monitoring by the stock exchange authority the specialist is restricted to earn zero expected profits. The specialist sets the narrowest bid-ask spread, conditional on the zero expected profits condition. All limit orders are executed and balanced by changes in the specialists inventory. The specialist share the same information set as the uninformed liquidity traders.

The informed investor (information block) have the following trading behavior. With probability one half he will buy the maximum g shares (in the case of zero private benefits) and with probability one half he will sell g shares (in the case of positive private benefits). Short sales is allowed. We assume that the probability to be caught for "insider" trading is small enough to ignore. The information block does not have any liquidity purposes for trading. The third type of investors are the liquidity traders. The liquidity traders are solving an unmodeled personal tradeoff between current and future consumption.

The volume of liquidity traders depend on the absolute difference between the transaction bid and ask prices and p^*. Let the ask price be $p_d = p^* + s_d$ and bid price $p_s = p^* - s_s$. The assumed aggregate demand and supply of shares by liquidity traders is

$$q_d(s_d) = q^* - \delta(p_d - p^*) = q^* - \delta s_d$$
$$q_s(s_s) = q^* - \delta(p^* - p_s) = q^* - \delta s_s$$

Delta is a measure of the sensitivity of volume to the spread. Delta is the same for the demand and the supply side. From this it follows that the bid-ask spread is symmetric around p^* and

$s_d = s_s = s$. Therefore the bid-ask spread is $2s$, see Benveniste et al. (1992). Henceforth, I refer to s as the spread.

In equilibrium the specialist sets bid and ask prices so that she earns zero expected profits and without being able to distinguish between informed and uninformed investors. From liquidity trade; every time the specialist executes the demand and supply of one share she makes a net revenue of $2s$. Let $R(s)$ denote the specialists net revenue from liquidity trade.

$$R(s) = 2s(q^* - \delta s)$$

We now look at the cost per share to the specialist from trade with the information block. In the case of zero private benefits the intrinsic value of the share is $\frac{1}{J}v$ and the informed wants to buy a share at the price $p_d = p^* + s$. The cost to the specialist is the difference between the intrinsic value of the share and the price received, thus, $\frac{1}{J}v - (p^* + s)$. Since $\frac{1}{J}v - p^*$ is the absolute difference between the date zero and date 1 intrinsic value, ρ, we can write the per share cost to the specialist as $(\rho - s)$. In the case of positive private benefits the intrinsic value of the share is $\frac{1}{J}(v - b)$ and the informed wants to sell a share at the price $p_s = p^* - s$. The cost to the specialist is the difference between the price paid and the intrinsic value of the share: $(p^* - s) - \frac{1}{J}(v - b)$. Noting that $p^* - \frac{1}{J}(v - b)$ is the absolute difference between the date zero and date 1 intrinsic value, ρ, we can write the per share cost to the specialist as $(\rho - s)$. So, the per share cost to the specialist is the same whether the informed is selling or buying shares, namely $(\rho - s)$. As the owner of the information block will trade g shares the specialist faces the following total costs, which is also the total date 2 profits to the information block:

$$C(s) = g(\rho - s)$$

In equilibrium the specialist sets the spread, s, such that

$$R(s) = C(s)$$

Substituting for $R(s)$ and $C(s)$ gives the quadratic equation

$$2s(q^* - \delta s) - g(\rho - s) = 0.$$

From this equation there will usually be two zero profit spreads. Through competition only the smallest spread will emerge in equilibrium. Solving the quadratic equation for the smallest spread (around p^*), yields

(1) $s = \frac{(2q^*+g)-[(2q^*+g)^2-8\delta\rho]^{1/2}}{4\delta}$

It is important to note that there are parameter values for which the specialist cannot balance the profits from liquidity traders with the costs from trading with the information block. If so, the market breaks down and there will be no trade. More specifically, if the information advantage parameters ρ and g are large relative to the volume of liquidity traders the specialist cannot set a bid-ask spread large enough to make zero profits and at the same time facilitate market trade.

Assumption 1. $\rho < \frac{(2q^*+g)^2}{8\delta g}$.

From assumption 1 it follows that the markets are open. Partial derivatives of equation (1) gives: $s_\delta(\cdot)>0$, $s_\rho(\cdot)>0$, $s_{g_i}(\cdot)>0$, $s_{q^*}(\cdot)<0$. The equilibrium spread is increasing in the amount of shares traded by the information block (g_i), ρ and the sensitivity to transaction costs (δ). The equilibrium spread is decreasing in the volume of liquidity trades (q^*).

Since the specialist makes no expected profits from trade at date 2, the specialist should neither make any expected profits or losses from the inventory bought at date 0. Therefore, the specialist pay the intrinsic value, p^*, for each share at date 0.

At date 3, dividends and private benefits are realized. The non-controlling shareholders and the founder receives the payoffs; $c_n v - c_n b$ and $\alpha v - \alpha b + b$, respectively, in the case of private benefits and $c_n v$ and αv, respectively, in the case of zero private benefits.

Project A or B?

At date 0, information blocks are formed and the founder decides on which project to undertake and maximizes the revenues from the initial selling of shares, his wealth at date 3 and private benefit extraction.

Assumption 2 $M < g(\rho - s)$.

From assumption 2 it follows that the gains from being the information block that receives the private signal is higher than the fixed cost of effort, M. We argue that in equilibrium there will be only *one* information block. The gains from speculating on the private signal is known by potential information block owners and does not depend on the number of information blocks. However, as information blocks are formed the expected value of an information block decreases, since the probability of being the one who receives the private signal decreases. At the same time every information block pays a fixed cost, M. It follows that once a new information block is formed a coalition of all the existing information blocks would be willing to pay a higher price for this ownership block than the potential new owner of the information block. The gains to the coalition of existing information blocks (or board members) from having one less information block is the same as the potential gains to the new information block from having a chance to get the private signal. But the existing information block owners have already incurred the fixed cost, M, contrary to the new member. This argument carries over until there is only one information block. In equilibrium, the one information block will own an ownership block large enough to preclude another party from sizing an information block. The owner of the information block can fill in the empty seats at the company board with family members or legal representatives. Hence, in equilibrium there is only one information block and $c_n^{ib} > [(1-\alpha)-\gamma]$.

At date zero the share price will be p^* and the premium (price paid above the intrinsic value) for the information block will be $g(\rho - s) - M$. At the initial selling no trade is motivated by liquidity purposes and the specialist and information block owner pay a share price equal to its intrinsic value, p^*. Competition among potential block owners will drive the premium paid for the information block to its date 2 value (following speculation on private information), net of the fixed cost of effort, M. At date zero, all shareholders end up paying their reservation price. The founder capitalizes on the premium paid for the information block. The rents go to the founder at the expense of liquidity traders. At date zero the founder is maximizing

(2) $V^F = [\frac{1}{2}(1-\alpha)v + \frac{1}{2}(1-\alpha)(v-b) + g(\rho - s) - M] + [\frac{1}{2}\alpha v + \frac{1}{2}(\alpha(v-b)+b)]$

In the first brackets is the founders welfare from the initial selling of shares which is the $(1-\alpha)$ selling of shares at its intrinsic value plus the premium for the information block net of the fixed costs M. In the second brackets is the date 3 expected dividends and private benefit extraction. Since the private benefit extraction is a pure transfer mechanism and investors are rational, equation (2) can be simplified to:

(3) $Max_{\{A,B\}} V^F = v + g(\rho_i - s_i) - M$ where $i = A, B$

Inspection of (3) gives partial derivative, $V^F_{\rho_i}(\cdot) > 0$. A higher variance of b (from project B to A) increases the value of the private signal and increases ρ, though there is also an increase in the spread, s. Therefore

Proposition 1. The founder chooses project A with b_{high} and higher expected expropriation when the effects of increased insider information is not offset by the larger spread, s_A.

3. Conclusion

In this paper we analyze a model of a founder going public and retaining control over ownership and management in an environment of poor legal investor protection. In our model the potential for private benefits is uncertain and board members elected by non-controlling ownership blocks can absorb private information about the realization of the private benefits. In the presence of liquidity traders the board member can trade on her private information and the non-controlling ownership block will sell at a premium. When greater uncertainty comes with higher expected expropriation, we find that it may be in the founders interest to commit to a project with high expected expropriation of outside shareholders. In equilibrium there will be one non-controlling ownership block that allows for the election of board members.

The model suggest interesting topics about family firms in regimes with poor legal investor protection. At the going public, the founder may have adverse incentives in term of constraining herself to little expropriation and the role of a large non-controlling shareholder may not be to monitor the family but to gain insight about the private benefit diversion. Hence, we should observe premiums paid for, not only the controlling block, but also significant ownership fractions.

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