A Study of Incentives in Three Layer Hierarchies

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to my grandfather Hüseyin Deniz, his curiosity for knowledge always inspired me...

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"A Study of Incentives in Three Layer Hierarchies"

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Economics,MA Thesis

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Abstract

The thesis studies the relationship between the fabrication of evidence and corruption decision of the Agent. To further study the effects of above mentioned fabrication of evidence event, the thesis also analyzes the effect of supervision and incentive scheme organization, within a three layer hierarchial system on corruption. We analyze both pure and mixed Nash Equlibrium strategies. The thesis analyze both non-cooperative and cooperative game structures. In cooperative games, we have also tackled the relationship between the ex-ante and ex-post collusion proof incentive schemes.

Keywords: corruption, corruption evidence, fabrication, supervision, incentives, collusion

" Üç Katmanlı Hiyerarşilerde Teşviklerin Çalışılması"

Emine Deniz

Ekonomi, Yüksek Lisana Tezi

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Özet

Bu tezde oyuncuların yolsuzluk kararları ile yolsuzluğa ait kanıtların yeniden üretilmesine arasındaki ilişki incelenmiştir. Bu ilişkiyi inceleyebilmek için yolsuzşuğa ilişkin kanıtların yeniden üretilmesi ile birlikte, denetim ve teşvik planlarının organizasyonunda yolsuzluk kararı üzerindeki etkisi araştırılmıştır. Bu tezde, hem anlaşmalı hem de anlaşmasız Nash dengeleri tartışılmıştır. Anlaşmalı Nash dengeleri çalışırken, önceden karar vrilmi ve oyun sonrası yapılan muvazaa arasında, teşvik yapılandırması açısından, ilişki incelenmiştir.

Anahtar Sözcükler: yolsuzluk, yolsuzluk kanıtı, yeniden üretme, denetim, teşvik, muvazaa

Contents

1 Introduction . . . 1
1.1 Literature Review . . . 3
2 Model . . . 9
3 The Analysis in The Absence of Collusion . . . 15
3.1 Pure Strategy Nash Equlibria . . . 15
3.1.1 Inducing the Strategy {Monitor,Corrupt,Fabricate} . . . 15
3.1.2 Inducing the strategy profile {Monitor,Corrupt,Not Fabricate} . . . 18
3.2 Mixed Strategy Nash Equlibria . . . 19
3.2.1 Inducing the strategy profile {Supervisor Monitors and Fabricates,Agent Randomizes} . . . 19
3.2.2 Inducing the Strategy Profile {Supervisor Monitors and Not Fabricates;Agent Randomizes} . . . 22
3.2.3 Inducing the strategy profile {Supervisor Randomizes and Fabricates, Agent is Corrupt} . . . 25
3.2.4 Inducing the Strategy Profile {Supervisor Randomizes and Not Fabricates,Agent is Corrupt} . . . 27
3.2.5 Inducing the strategy profile {Supervisor Randomizes and Fabricates, Agent Randomizes} . . . 27
3.2.6 Inducing the strategy profile {Supervisor Randomizes and Not Fabricates,Agent Randomizes} . . . 30
4 The Analysis in The Existence of Collusion . . . 35
4.1 The Ex-Post Collusion Analysis . . . 35
4.2 Ex-Ante Collusion . . . 38
5 Concluding Remarks . . . 41

1 Introduction

There are many different definitions provided for corruption and corrupt behavior. The most recognizable and well known example of corruption is the public officials accepting bribes for permit or licence. However, one should note that corruption includes individual oppurtunistic behavior such as shirking on the job,absenteeism and favoring friends and relatives in recruitment and promotion[1]. So, we can broadly define corruption as adaptation of individual oppurtunistic behavior for private gain.

Corruption is usually modeled in Principal-Agent relationships and it is mainly the agent who is engaged in the corrupt behavior. A public officer who has discretionary power on distributing a permit or a licence can engage in corruption by accepting bribes. A worker in a factory can engage in corrupt behavior by exerting low effort levels or taking leaves of absence frequently. Moreover, the secrecy of corrupt behavior causes a hidden action problem.

The hidden action problem entails two sub-problems. In a framework where hidden action is observed,monitoring becomes substantially important. The Principal either performs monitoring herself or delegate monitoring duty to an independent supervisor. Monitoring requires a costly technology and the technology adopted is imperfect. Notwithstanding the necessity of monitoring in hidden action enviroment, note that there are some cases, pure strategy Nash Equlibria where the Agent is corrupt with probability one, the Principal does not need to monitor.Under the assumption that the technology adopted for monitoring is costly, the Principal simply does not prefer monitoring, either conducted by herself or supervisor. On the other hand, even under a costly monitoring technology, the Principal may always prefer monitoring to be conducted. To induce monitoring, the Principal sets high penalties for not monitoring.

The second sub-problem that needs to be dealt in hidden action enviroment is the establishment of incentive schemes. In our framework, we deal with incentive schemes. Incentive schemes are designed to provide "incentives" for the agent to perform an desired action. Incentive schemes are designed under considerations such as; the incremental benefits, i.e. payoffs, profits, created by additional effort, the precision with which the desired activi-

[1] Bac,M. "Corruption, Supervision and the Structure of Hierarchies" Journal of Law,Economics and Organization 1996

tiesare assessed, the agent's risk tolerance and the agent's responsiveness to incentives. The Principal always prefers the agent who is honest and hard working, however she does not always prefer to induce that kind of behavior. Additional effort is costly, so to create incremental benefits high incentive schemes are needed to be offered. On the other hand, any kind of corruption causes harm to the principal. So as the harm done by the corruption increases, the principal's preference on inducing desired behavior also changes.Assessment of the agent's output is based on the monitoring effort exerted, either monitoring is performed by the principal or the supervisor. If the monitoring is performed by the supervisor, then the principal may prefer to offer incentive schemes that will induce monitoring behavior. However, we assume that monitoring technology adopted is costly, so the incentive scheme offered to the supervisor should compensate the cost inflicted due to monitoring. All the player's in the game are assumed to be risk neutral in our framework. To answer the question of how to design optimal incentive schemes in order to prevent corruption is one of the main objectives of the thesis.

The thesis is mostly related to literature on corruption and monitoring. We contribute to the literature in a way that we link the fabrication of evidence event to the corruption literature. In corruption literature there are mainly two types of outcomes that can be reached at the end of the Principal-Agent game, i.e. corrupt or honest, high output, low output etc.. The game we modeled in the thesis has three outcomes, which are referred as "corruption evidences". There are three outcomes, corruption evidences, in the game: hard, soft and no evidence. Hard evidence is non-deniable indicator of corruption. Soft evidence on the other hand has links to corruption with positive probability but it is not a definite sign of corruption. There exists also a positive probability that soft evidence can be reached even if the agent is not corrupt. No evidence as name suggests contains no information on the action of the agent. No evidence can be reached whether the agent is corrupt or not, and/or whether the supervisor monitors or not.

Fabrication of evidence event can be observed when a supervisor who chooses to monitor reaches no evidence. Since monitoring technology is imperfect a monitoring supervisor reaches, with positive probability, to no evidence outcome. At that point of the game, supervisor may present no evidence, with some additional traits, as soft evidence to the principal. So soft evidence by nature can be fabricated. Also, the principal cannot distinguish between a real soft evidence and a fabricated one. On the other hand, the supervisor, unless it is a pure strategy Nash Equlibria, can not differentiate between "no evidence" outcomes. That is to say, when he observes no evidence outcome, he does not know whether the agent is corrupt or not. In that case, when the supervisor decides upon fabricating evidence with positive probability he will be framing an honest agent. Although, soft evidence is not a definite sign of corruption it still brings disutility to a honest agent. Also, we introduce a monetary equivalent of harm done both to the honest agent and the principal by fabrication of evidence.

The thesis tries to link fabrication evidence to corruption literature in order to analyze the effect of fabrication on agent's corruption decision. Like monitoring technology fabrication of evidence is also costly. The fabrication of evidence event makes the soft evidence incentive scheme payments more likely. Our intutiton has been that given the fabrication of evidence, the agent decides upon honesty. And also we try to analyze the cost reducing effects, if there are any, of fabrication. We try to analyze if there exists a cost reduction for any outcome that the principal may prefer to induce.

Also, collusion is common phenomenon is principal-agent relationship. The agent and the supervisor can cooperate if there exists an additional surplus, created by cooperation, that is to be shared. The principal's incentive scheme in that case, in addition to all those above, also includes collusion-proofness. We examined two types of collusion, ex-ante and ex-post. Ex-ante collusion is an agreement between the supervisor and the agent that requires not monitoring decision from the supervisor. Whereas, ex-post collusion proofness is an aggrement where the supervisor reports no evidence when he reaches hard or soft evidence.Then, we try to see if there exists a relationship between ex-ante and ex-post collusion.

While continuing with the results and characterizations we have provided within the thesis, we would like to remind you that all the results and characterization we have provided are structured by the assumptions we have made, enviroment we have created.

1.1 Literature Review

In this section, we discuss the related literature on corruption, incentives,hierarchy and fabrication in order to highlight the contribution of the present thesis. In our framework, we introduce the fabrication of "corruption evidence". While we know of no paper in which the issue of fabrication of corruption evidence, there are many separate theoretical studies of corruption and fabrication. We discuss a selection from these papers belows.

Sah and Stiglitz (1986) studies the effect of organization of the decision-making units together on the performance of an economic system or organization.The paper called this organization of decision making units as "architecture". The architecture is defined as the description how the constituent decision-making units are arranged together in a system, how the decision-making authority and ability is distributed within a system, who gathers what information, and who communicates what with whom. There are two specific architectures studied in the paper,*polyarchy and hierarchy. A polyarchy* is an architecture, in which there are several, and possibly competing, decision makers who can undertake projects independently of one another. That kind of architecture is considered feasible in market-oriented economies. On the other hand, *a hierarchy* is a concentrated model, where a group of individuals, or sometimes only one individual, can undertake projects while the others provide support in decision making. That architecture is considered feasible for bureaucracy-oriented economy. The paper mainly focuses on the effect of choice of architecture on the quality of decision making. That is to say, how individuals are arranged affects the nature of the errors made by the economic system.They exemplify their research question as follows; in a market economy, if one fimr rejects a profitable idea, there is a possibility that some other firm might accept it. In constrast, if a single bureau makes such decisions then the idea remains unused. The logic works both ways of course. Their analysis is based on a technology, which has two important central features: the costs of acquiring and communicating information and limited capabilities of individuals to gather,absorb and process information within a limited amount of time.Next,they provide a model of the decision structure within a polyarchy and a hierarchy. Then, they continue their analysis under the assumption that the nature of an individual's errors and the mix of available projects is exogenous, and analyze the relative performance of the architectures under these assumptions. Finally, the analysis compare the relative performance of the architectures with regards to collection and processing of information. They conclude that their analysis provides insight for the arguments on the relative merits of polyarchies vs the hierarchies. They provide the assesment of the circumstances under which one architecture is better than the other.

Following the discussion on the effect of design of organizational systems on (economic) systems' performance, *Yingyi Qian (1994)* studies the incentives and loss of control in a hierarchy model. In the model, the levels of effort from managers and workers, the wage scales, the span of control and the total number of tiers are all endogenous. The analysis raised in the paper is based on the determination of hierarchial tiers, the span of control, i.e. the number of subordinates under the same supervisor and the wage scales in the hierarchy under an organizational design problem. The amount of capital and the state of technology are taken as given. The paper provides a model for an economic organization that owns a capital stock,K, and uses a hierarchy to control the production.A superior can be in charge of one or more subordinates, however to simplify the analysis subordinates have only one superior. The superior monitors the subordinates effort level, which is either zero or one, in the second part of the analysis the paper analyze the continous effort scheme also. The superior's monitoring technology requires only time and no effort.When the superior monitors the subordinate, the effort level can be known precisely. However, the superior has limited time,i.e. the superior can monitor his subordinates with a probability, $P<1$. The paper concludes with two main results, under a specific monitoring and production technology. First, in the optimal hierarchy in which all managers and workers are identical ex-ante,wages fall and efforts decrease as one moves from the top to the bottom of the hierarchy. Second, as the size of the hierarchy increases both the efforts and wages of managers at the top increase because their marginal product increases, and both the efforts and wages of workers fall because their marginal product decreases. Hence, the wage ratio between the top managers and workers increases.This result implies a greater loss of control for a bigger hierarchy.

The enviroment analyzed in the thesis requires adoptation of hierarchial architecture. We established a three layer hierarchial setting composed of the Principal, the Supervisor and the Agent. Also, there is only one principal, one supervisor and one agnent in the game. So, span of control is not an issue in the game. However, further studies may include more than one supervisor, in either hierarchy and poliarchy architectures, and also more than one agent to analyze the effect of incentive schemes and fabrication of evidence on corruption.

Mehmet Bac (1996) studies the relation between monitoring and corruption under different hierarchies.In order to understand the relation between structure of the hierarchy and the corruption,the incentive structure, wages and rewards, are exogenous. Exogenous incentive structure entails the same wages for all agents and same rewards for all supervisors. The monitoring technology choice is of great importance to understand the relationship between a monitoring hierarchy and corruption. There are two polar types of monitoring technology: public and private. The former is simultaneous monitoring of a group of subordinates by supervisor. The latter is monitoring of a particular subordinates by supervisor. As stated in the paper besides the monitoring technology, another relevant issue is the nature of corruption. External corruption, referring to transactions between a member of the organization and an outsider. Then, the paper introduces the second kind of corruption,internal corruption. Internal corruption is defined as an implicit agreement, whereby the subordinates transfer a portion of proceeds from external corruption to the upper levels.Internal corruption allows for a type collusion eliminating the monitoring in the hierarchy. Last but not least, the paper provides as with the nature of hierarchial structure. The flat hierarchy refers to minimal one rank extension that consists of a supervisor at the top and a group of subordinates who are monitored at the bottom. The steep hierarchy, on the other hand, is maximal one rank extension in which each supervisor monitors only one subordinate. Given the monitoring technology, the trade off is between the external and internal corruption in flat and steep hierarchial structures. The paper concludes that under public monitoring external corruption is less likely in a flat hierarchy than a steep one. However, under public monitioring flat hierarchy is more susceptible to internal corruption than steep hierarchy. For private monitoring, since monitoring costs increases as the monitoring efforts increases, supervisor's monitoring incentive is so low that all subordinates are corrrupt in flat hierarchy. The type of monitoring technology does not matter for steep hierarchy.

Ronald Strausz (1997) paper differs from the rest of the literature we have been reviewed from its structure in monitoring. The paper studies a principal-agent relationship in which either the principal or a supervisor can monitor the agent's hidden action by the use of identical monitoring technology. So, the question is whether the principal should delegate its monitoring duty or not. The problem is analysed in a simple agency setting with hidden action. Costly monitoring of the agent's action is possible and can be performed by either the principal or an independent supervisor. There are two important assumptions on monitoring technology; monitoring is not verifiable and monitoring signals are private information.The paper concludes that delegation of monitoring is profitable. This results is due to first the assumption that monitoring is non-verifiable and therefore non-contractable transforms the principal-agent problem into a problem with double moral hazard. Apart from inducing the agent to take high effort level, the principal needs also a set appropriate incentives to induce monitoring, as the agent will not choose a high effort level if monitoring does not take place. The principal, therefore, has to create two types of incentives. When the principal does not delegate monitoring, she has only one contract through which she can regulate both incentives.If the principal does delegate monitoring, then she has also the contract of the supervisor by which she can create incentives. The paper concludes that with two contracts the principal is able to regulate the two incentives more accurately and find that the delegation has an incentive effect. Second reason for the profitability of the delegation of monitoring is the assumption that information, which is obtained from monitoring process, is private. The private nature of the information implies that the monitor has to decide whether to reveal information or not. This causes delegation to have a commitment effect. The paper shows that when the principal delegates monitoring,it is optimal for her to use a carrot and stick approach to induce the agent to take the right action. When the principal monitors, she is reluctant to deliver the carrots, i.e. she is reluctant to reveal the information gathered from monitoring when the effort level of agent is high. When the principal employs an independent supervisor, she will be able to use carrot-stick approach optimally.

The thesis mainly follows the environment described Strausz's paper. The thesis studies a principal-agent relationship alike, however unlike Strausz's paper, the thesis studies whether the monitoring is always necessary or not. The outcomes of the game in Strausz's paper is twofold: high effort outcome and low effort outcome. The outcomes are stochastic, and also exerting high effort does not necessarily mean that the outcome realized is going to be high effort outcome. The thesis follows the same logic, with three outcomes, and realization and/or fabrication of soft evidence even when the agent is honest.

All those papers we have mentioned above incorporated Cooperative Nash Equilibrium as well as Non-Cooperative Nash Equilibrium. One of the most prominent papers on collusion is by *Tirole (1986).* The paper derives its motivation from sociological studies of collusive behavior in organizations. Sociological studies in the area state that collusive behavior is predicted by the analysis of group as well as individual incentives. In his paper, *Tirole* incorporates information economics into that sociological theory. The paper also borrows from the principal-agent paradigm of the information economics. This paradigm emphasizes the productive inefficiency associated iwth asymmetric information and insurance motives. The theme of paper, however, is that the analysis of the hierarchial structures does not boil down to a compounding of the basic inefficieny, due to the fact that going from the simple two-tier principal/agent structure to more complex ones introduces the possibility of collusion. The paper, on the other hand, views an organization as a network of contracts that interplay rather than as a single contract. The paper concludes that collusive behavior decrease the efficiency of the hierarchial structure. So, collusive behavior must be fought through incentive mechanisms. However, then the paper remarks the reader that that conclusion is extreme. Sometimes, the side transfers exist because the organization needs them to sustain long-term relationship in all levels of hierarchies.

Following the *Tirole's 1986* paper, *Bac* and *Kucuksenel (2005)* extend the model of hierarchy by incorporating the relationship between ex-ante and ex-post collusion and the supervisor's monitoring incentives. The paper differs from the collusion model presented in *Tirole's* by the introduction of the supervision costs and a new, ex-ante,occasion for collusion whereby the supervisor stops monitoring for a transfer payment from the agent, in addition to ex-post collusion possibilities conditional on the monitoring outcome. The paper conludes that that ex-ante collusion and the supervisor's incentive constraint can be ignored when the monitoring costs are small and the probability of succesful detention is large. Also, to prevent ex-ante collusion the principal increases the gap between the wages offered when a report is presented and not.

We follow the analysis done in the *Bac* and *Kucuksenel(2005)* paper. We analyze the relationship between ex-post and ex-ante collusion. We try the answer the question, whether the ex-post collusion proofness is sufficient to prevent ex-ante collusion.

Our paper introduces the notion of "framing" by fabrication of evidence in three layer hierarchy modeling. One of the paper's on framing is by *Polinsky and Shavell (2000).*The paper mainly analyzes the corruption in law enforcement, the payment of bribes to enforcement agents, threats to frame innocent individuals in order to extort money from them and the actual framing of innocent individuals. The paper concludes that taking bribes and framing should be penalized maximally, however extortion should not be penalized. This counter-intuitive conclusion is due to the fact that, penalizing extortion either raises the expected payment of innocent individuals if extortion is not deterred, or else induces enforcers to frame rather than extort such individuals, in the model they have provided. If the assumptions of the model has been changed, there is a chance that the conclusion can be changed.

The thesis is organized as follows. The next section presents the model in which we adress the question "What are the optimal incentive schemes that should be introduced in three-layer hierarchies". In Section 3, we begin our analysis under the absence of collusive behavior. We characterize the optimal incentive scheme that has to be offered to induce pure strategy Nash equlibria, of the non-cooperative game. Then, we characterize the incentive schemes that induce desired behavior in mixed strategy Nash Equilibria of the non-cooperative game.

In section 4, we extend our analysis to collusive behavior. We follow the *Bac and Kucuksenel (2005)* and introduce two types of collusion, ex-post and ex-ante collusion.

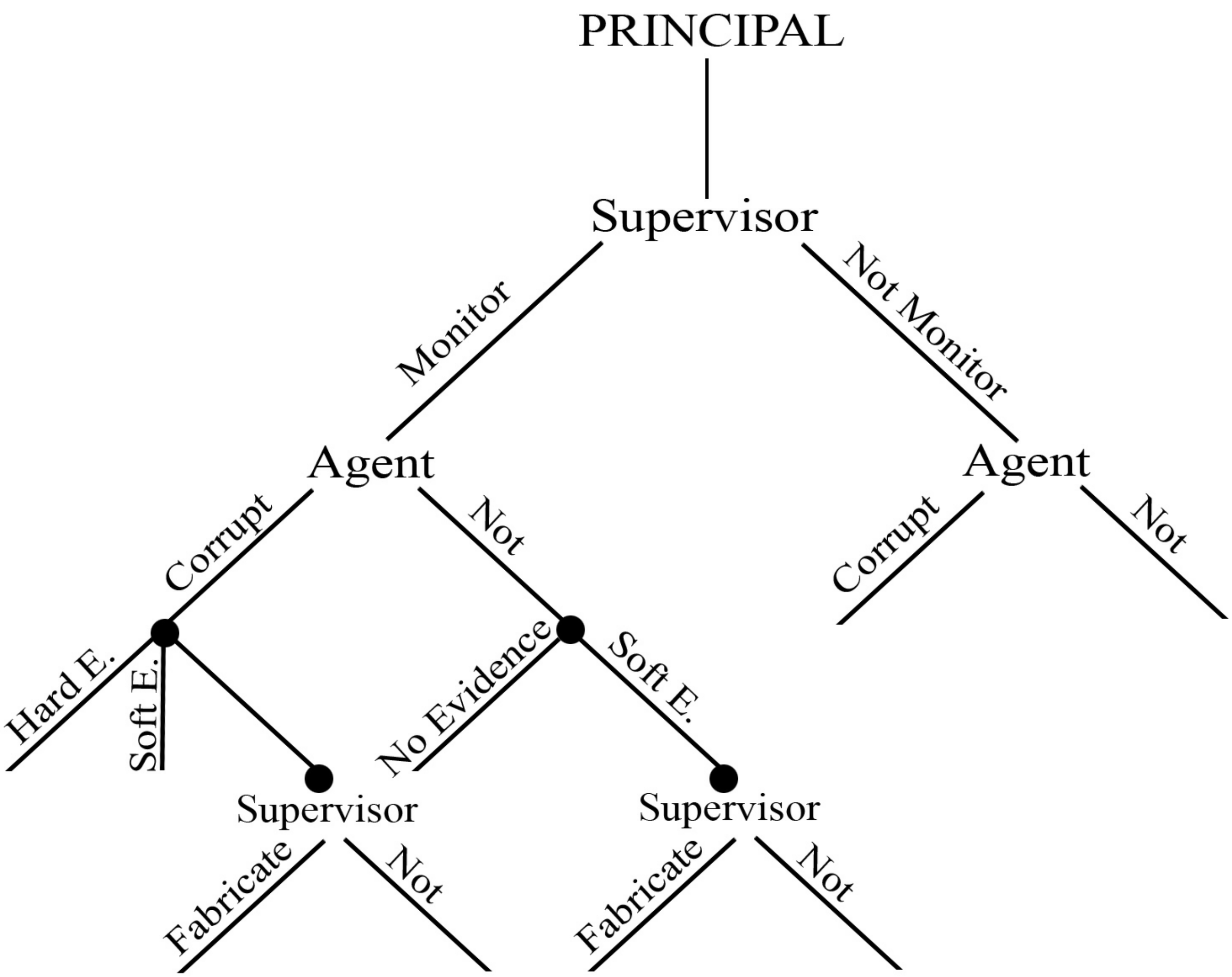
Section 5, concludes the thesis by summarizing the results we have discussed and extending more research questions in the topic.

2 Model

In the thesis we model the game in a three-layer hierarchial system.The highest ranking player in the game is the Principal. The Principal's objective is to minimize her expected cost, which is composed of wages offered to the supervisor and the agent under hard, soft and no evidences. The Principal hires both the Supervisor and the Agent. The Supervisor is hired by the Principal to perform monitoring. He decides between monitoring and not monitoring actions. The Supervisor is able to observe and verify the outcomes of the game. The Supervisor's objective is to maximize his utility, which is the expected payoff he gets from performing, induced, action. The lowest ranking player in the game is the Agent, and he is also hired by the Principal. He can be either a public official who distributes permits and licences or a factory worker who is engaged in manufacturing. Just like, the Agent's objective is to maximize his expected utility.

An outcome in the interaction between the Supervisor and the Agent is defined as an "a corruption evidence". Outcomes,i.e. types of corruption evidence,are observable an verifiable. We distinguish between three types of evidence, according to their informativeness,or reliability.The most reliable outcome is classified as hard evidence, which is a non-deniable indicator of the corruption. Due to its unmistakable nature, hard evidence can only be reached if the Supervisor monitors and the Agent is corrupt. The next outcome is the soft evidence, which can be reached if the Supervisor monitors, (the Agent is corrupt or not).So, unlike hard evidence, soft evidence cannot be regarded as a proof of corruption. The last outcome is "no evidence", as the name suggests, evidence that has no information value,revealing nothing new. The no evidence outcome can be reached as a result of any action taken by the Supervisor and the Agent.

Below we introduce the notation and then describe the model and the sequence of the events.In this hierarchy, the Principal's wage payment can depend solely on the observable outcomes, i.e., evidence types, of which we have three. Thus, the incentive package can include three different wages for the Supervisor,$w_h^s, w_s^s, w_{n,}^s$, and three different wages for the agent, $w_{h,}^a w_s^a, w_n^a$.Some of these variables are further explained in the analysis.


PRINCIPAL
Supervisor
Monitor
Not Monitor
Agent
Agent
Corrupt
Not
Corrupt
Not
Hard E.
Soft E.
No Evidence
Soft E.
Supervisor
Supervisor
Fabricate
Not
Fabricate
Not

w_h^s : High evidence wage for the Supervisor
w_s^s : Soft/Fabricated evidence wage for the Supervisor
w_n^s : No evidence wage for the Supervisor
w_h^a : Hard evidence wage for the Agent
w_s^a : Soft/Fabricated evidence wage for the Agent
w_n^a : No evidence wage for the Agent
w_0 : Common reservation wage for the Supervisor and the Agent normalized to 0
c_m : Cost of monitoring for the Supervisor
c_f : Cost of fabrication for the Supervisor
z : The Agent's positive utility from corruption
h : The Principal's negative utility from the Agent's corruption
f^a : Harm faced by an honest Agent in case of fabrication
f^p : Harm faced by the Principal in case of framing of an non-corrupt Agent.
γ : The probability of the Agent being corrupt
q_1 :The probability of reaching hard evidence when the Agent is corrupt
q_2 : The probabilty of reaching soft evidence when the Agent is corrupt„
q_3 : The probability of reaching no evidence when the Agent is corrupt
μ : The probability of reaching soft evidence when the Agent is not corrupt.

It is natural to assume that harm done by the corruption is higher than the private benefit gained by the Agent by engaging in corruption. That is to say, the thesis analyzes the tools and incentive schemes that may prevent or decrease the adoptation of corruption. Since we are dealing with prevention, we clearly and naturally assume that corruption is "bad".

The probabilities, assigned by the nature, q_1, q_2 and q_3 sums up to one. And the probabilities of the Supervisor monitoring,p, and the Agent being corrupt, γ, is endegenous. They are determined through the incentive schemes that the Principal offers.

It is useful to assume that $c_m > c_f$. Once the Supervisor decides upon monitoring, he bears the cost of monitoring, c_m which is incurred due to monitoring technology. On the other hand, once monitored with positive probability he reaches hard and soft evidence. If he reaches no evidence, which is possible with probability q_3 and decides upon fabricating evidence he bears the cost of c_f. That cost is smaller than c_m because once the supervisor monitors and reaches a evidence, no evidence, it is less costly to generate "new" evidence.

That new evidence is soft, which can be reached by a monitoring supervisor whether the Agent is corrupt or not.

The probabilities of the Supervisor monitoring and the Agent being corrupt can directly been influenced by the wage structure offered by the Principal, whereas the probabalities of hard,soft and no evidence are exogenous parameters that are defined by the nature.

The game starts with the Principal's offer to both the Supervisor and the Agent. The offer contains wages provided upon the outcomes of the game, hard,soft and no evidence. The Supervisor and the Agent accept the offer if their participation constraints are satisfied. The Principal also operates under a limited liability constraint: in no outcome of the game can the Principal impose a positve transfer on the Supervisor and/or the Agent. In other words, the wage payment must be non-negative.

The Principal's objective is to minimize an expected cost expression, defined and stated in the sequel, which includes expected wage payments and costs that arise from the actions taken in the hierarchy.

The following is the sequence of events in the game.

- Principal offers wage contracts,
- The Supervisor and the Agent accept or reject,

Then, if they both accept, the two play a simultaneous-move game in which the Supervisor chooses to monitor the Agent or not, and the Agent chooses between corruption and remaining honest. The outcome of this interaction is determined by the Nature and is observed only by the Supervisor. If the outcome is "no evidence", the Supervisor msy decide to fabricate soft evidence.Participation constraint satisfied the Supervisor and the Agent opt to play a simultaneous move game. The Principal's objective is to minimize her costs by offering the lowest possible wages to the Supervisor and the Agent that will induce the desired behavior.

All payoffs are measured in the same,common unit.The final payoffs in the game are determined as follows:

The Supervisor, monitoring, will receive the payoffs: $w_h^s - c_m$, $w_s^s - c_m$ and $w_n^s - c_m$ in case of hard,soft and no evidence respectively.

The Supervisor,not monitoring, will receive the payoff: w_n^s

The corrupt Agent will receive the payoffs; $w_h^a + z$, $w_s^a + z$ and $w_n^a + z$ in case of hard,soft and no evidence respectively.

The non-corrupt Agent will receive the payoffs w_s^a and w_n^a under the monitoring Supervisor.

If the Supervisor does not monitor, the payoff will be w_n^a $+z$ and w_n^a for the corrupt and non-corrupt Agent respectively.

The Supervisor cannot reach undeniable indicator of the corruption,hard evidence, at all times. The monitoring strategy is imperfect. After realization of the outcomes as a result of the simultaneous move game, the Supervisor will move again if the outcome is; no evidence. The Supervisor will decide whether to "fabricate" evidence or not.

Fabricating soft evidence to frame the Agent is a costly activity for the Supervisor.If the Supervisor decides to fabricate evidence, he has to exert an effort, $c_f > 0$. The Supervisor who monitors will reach "no evidence" with positive probability, q_3 and $1 - \mu$ when the Agent is corrupt and honest respectively. He will decide whether to fabricate or not, the fabricated evidence will be classifed as "soft evidence". So both the corrupt and honest Agent is susceptible framing. However, only the honest Agent will bear a disutility $f^a > 0$ in monetary terms.The Principal cannot to identify between "fabricated" and "real" soft evidence. Also, the Principal will face a disutility of $f^p > 0$ in monetary terms when the non-corrupt Agent is framed.

The payoff structure in case of fabrication will be as follows:

$w_s^s - c_m - c_f$, $w_s^a + z$ for the Supervisor and the corrupt Agent respectively

$w_s^s - c_m - c_f$,$w_s^a - f^a$ for the Supervisor and the non corrupt Agent respectively.

In the first part of the analysis,we characterize the optimal wage structure in the absence of collusive behavior.When the outcomes are realized, the Supervisor will submit a report, i.e.announce the outcome to the Principal. He will not withhold information from the Principal in agreement with the Agent. He can however, fabricate evidence.We shall focus first on the Pure Strategy Nash Equlibria, then we will investigate optimal incentives and minimized costs when the Supervisor, the Agent or both randomize.

3 The Analysis in The Absence of Collusion

3.1 Pure Strategy Nash Equlibria

The most preferred outcome from the Principal's perspective are:

{Monitor,Not Corrupt and Not Fabricate} or {Not Monitor, Not Corrupt and Not Fabricate}. However, these cannot be identified as Nash Equilibrium of the monitoring-corruption game, because the players, i.e. the Supervisor and the Agent, will be better of by deviating. That is to say, the Supervisor, who monitors will deviate to not monitor strategy given that the Agent is remaining honest. Also, the Agent, who is remaining honest will deviate to corruption given that the Supervisor is not monitoring.

These observations leave us with two possible Nash Equilibria:

- {Monitor,Corrupt,Fabricate}
- {Monitor,Corrupt,Not Fabricate}

Clearly, if the Principal's objective is to induce this equlibria, she can simply not hire the Supervisor (who is ineffective here). It is also inefficient to have an supervisor exert effort for absolutely no impact on the Agent.

Despite this fact, we shall solve the Principal's problem with the Supervisor who monitors, when the Agent is corrupt with the probability one, for he sake of completeness and illustrate the mechanics of the problem at hand.

3.1.1 Inducing the Strategy {Monitor,Corrupt,Fabricate}

In this case, the Supervisor decides to monitor and, if he reaches the no evidence outcome, he will fabricate evidence. On the other hand, the Agent chooses corruption. Given these choices, the Principal's expected cost will be as follows:

$$EC_p : q_1(w_h^s + w_h^a) + (q_2 + q_3)(w_s^s + w_s^a) + h$$

The Supervisor and the Agent's expected utilies and participation constraints are as follows:

$EU_s : q_1 w_h^s + (q_2 + q_3) w_s^s - q_3 c_f - c_m \geq 0,$
$EU_a : q_1 w_h^a + (q_2 + q_3) w_s^a + z \geq 0$

The Participation Constraints ensure that the expected utility from participating to the game is at least much as choosing the outside option,w_o, which is normalized to 0.

The Principal's objective is to minimize her expected costs subject to the participation constraints stated above and the limited liability constraints below:

$w_j^i \geq 0$ where $i : s, a$ and $j : h, s, n$

The limited Liability Constraint protects the Supervisor and the Agent from making payments to the Principal. The Principal cannot offer wages that will require the Supervisor and the Agent to actually "pay" to the Principal.

The additional constraint in this problem is:

$w_s^s - c_f \geq w_n^s$, which ensures that the Supervisor fabricates soft evidence.

Thus, the Fabrication Incentive seems to induce the desired outcome {Monitor,Corrupt,Fabricate}. The Principal has to offer wages such that the expected utility from fabrication is at least as large as the expected utility from not fabricating.We assume that if the payoffs from fabricating and not fabricating is equal, the Supervisor will choose the option which the Principal wants him to choose.

Finally we have Nash Equilibrium conditions:

$q_1 w_h^s + (q_2 + q_3) w_s^s - q_3 c_f - c_m \geq w_n^s$

$q_1 w_h^a + (q_2 + q_3) w_s^a + z \geq w_s^a - (1 - \mu) f^a$

The Nash Equlibrium conditions satisfies that the actions taken by the players in the hierarchial structure is deviation-proof. That is to say, the wage structure offered must ensure that neither the Supervisor nor the Agent are better off by deviating from their respective strategies.

The problem can be stated as follows:

$\min q_1(w_h^s + w_h^a) + (q_2 + q_3)(w_s^s + w_s^a) + h$

subject to

$$w_j^i \geq 0 \tag{LLC}$$

$$q_1 w_h^s + (q_2 + q_3) w_s^s - q_3 c_f - c_m \geq 0 \tag{PC$_s$}$$

$$q_1 w_h^a + (q_2 + q_3) w_s^a + z \geq 0 \tag{PC$_a$}$$

$$w_s^s - c_f \geq w_n^s \tag{FC}$$

$$q_1 w_h^s + (q_2 + q_3) w_s^s - q_3 c_f - c_m \geq w_n^s \tag{NE-C$_s$}$$

$$q_1 w_h^a + (q_2 + q_3) w_s^a + z \geq w_s^a - (1-\mu) f^a \tag{NE-C$_a$}$$

Proposition 1 *The PC_s is not binding, it holds for any non-negative wage,w_j^s. This is observed from NE-C_s coupled with LLC. Also observe that, LLC couple with the fact that z is non-negative imply that the Agent's participation constraint cannot be binding.*

Note that the first two terms in the RHS of NE-C$_s$ also appear in the Principal's cost objective. Given the fact that $w_n^s \geq 0$, we can choose $w_n^s = 0$ and $w_s^s = c_f$. So, the fabrication constraint holds and it is binding. With these wages, NE-C$_s$ will reduce to

$q_1 w_h^s + (1 - q_1 - q_3) c_f - c_m \geq 0$

Setting $w_h^s = \frac{c_m - q_2 c_f}{q_1}$ will satisfy all the constraints as well as minimizing the costs.

Observe that, the solution is not unique. For instance, for ε small enough,

$w_h^s = \frac{c_m - q_2 c_f}{q_1} - \varepsilon$

$w_s^s = c_f + \frac{\varepsilon q_1}{1 - q_1}$

$w_n^s = 0$ is also a solution.

The wage structure we have obtained is optimal. To show this, suppose on the contrary that they are not.This means there are other wages that generate smaller costs for the Principal.

Let us choose $w_n^s > 0$, in this case $w_s^s = c_f + w_n^s$, provided that FC is binding. The w_h^s that satİsfies constraints and minimizes the cost function will be: $w_h^s = \frac{c_m + q_1 w_n^s - q_2 c_f}{q_1}$ is higher than the wage we have obtained above. So contradiction occurs, the wages are optimal.

The wage structure for the {Monitor,Corrupt,Fabricate} case is as follows:

$W_s = (\frac{c_m + q_1 w_n^s - q_2 c_f}{q_1}, c_f, 0)$

$W_a = (0, 0, 0)$

Therefore, the Principal's minimized cost is;

$$EC_p : c_m + q_3 c_f + h \tag{I}$$

3.1.2 Inducing the strategy profile {Monitor,Corrupt,Not Fabricate}

The only difference from the first case is in the fabrication constraint. The Supervisor monitors the Agent, who chooses corruption, however the Supervisor does not fabricate evidence in the case of "no evidence". In that setting the expected cost of the Principal will be as follows:

$$EC_p : q_1(w_h^s + w_h^a) + q_2(w_s^s + w_s^a) + q_3(w_n^s + w_n^a) + h$$

The Supervisor's and the Agent's expected utility are now stated as:

$EU_s : q_1 w_h^s + q_2 w_s^s + q_3 w_n^s - c_m,$

$EU_a : q_1 w_h^a + q_2 w_s^a + q_3 w_n^a + z$

The first difference is the introduction of positive probability of receiving the "no evidence" wage for both the Supervisor and the Agent. Also, the Supervisor will not bear the cost of fabrication in that case.

Thus the Principal's problem is:

$\min q_1(w_h^s + w_h^a) + q_2(w_s^s + w_s^a) + q_3(w_n^s + w_n^a) + h$

subject to

$$w_j^i \geq 0$$

$$w_n^s \geq w_s^s - c_f$$

$$q_1 w_h^s + q_2 w_s^s + q_3 w_n^s - c_m \geq w_n^s$$

$$q_1 w_h^a + q_2 w_s^a + q_3 w_n^a + z \geq \mu w_s^a + (1-\mu) w_n^a$$

Following the same logic above, the optimal wage profile is:

$W_s = (\frac{c_m}{q_1}, 0, 0)$

$W_a = (0, 0, 0)$

With the cost function:

$$EC_p : c_m + h \tag{II}$$

Under the absence of collusion,and the players are not randomizing, the Principal will be better off by offering wages that will induce the {Monitor,Corrupt,Not Fabricate} equlibrium because th costs in II is smaller that those in I. Observe that, because $0 \leq q_3 \leq 1$ and $c_f > 0$,we have $c_m + h \leq c_m + q_3 c_f + h$. Since the Principal's objective is to minimize her expected cost, she will prefer the no fabrication case to the fabrication case. She will indifferent between the two options when the probability of reaching "no evidence", q_3, hence, fabrication, is equal to zero.

The solution to the Pure Strategy Nash Equlibria in the absence of collusion is intuitive. Since the Principal cannot force the Supervisor and the Agent to make positive transfers to her, she should offer wages that are greater than or equal to zero, in accordance with the limited liability constraint. Also, the Supervisor and the Agent have discretion over their decision on whether to participate in the game or not. They will participate only if their expected utility in participating the game is at least as high as their outside option, which has been normalized to zero in our model. In that case, the Principal should offer wages that will compensate for the cost of monitoring and fabrication. The Principal will prefer to induce the equilibrium with no fabrication hence, where she does not incur any fabrication cost.

3.2 Mixed Strategy Nash Equlibria

In this part of the analysis we analyze two distinct types of equlibria. First we analyze the equlibria in which one of the players (the Supervisor or the Agent) has a strict preference over one action while the other player is indifferent. Then we will move on with the equilibria where both players are indifferent.We have come up with six different equlibria which will be analyzed thorougly.

3.2.1 Inducing the strategy profile {Supervisor Monitors and Fabricates,Agent Randomizes}

Suppose that the Principal is interested in inducing an equilibrium in which the Supervisor will monitor with probability one, and if her efforts end up in no evidence she fabricates evidence, whereas the Agent is indifferent between engaging in corruption or not. His expected utility from both actions is the same.

The Principal's expected cost is as follows:

$$EC_p = \gamma q_1(w_h^s + w_h^a) + (\gamma q_2 + \gamma q_3)(w_s^s + w_s^a) + (1-\gamma)(w_s^s + w_s^a) + (1-\gamma)(1-\mu)f^p + \gamma h$$

where γ is the probability of the Agent being corrupt and f^p is the monetary equivalent of the disutility to the Principal due to framing of an honest agent.

The Principal's problem can be formulated as follows:
$\min \gamma q_1(w_h^s + w_h^a) + (\gamma q_2 + \gamma q_3)(w_s^s + w_s^a) + (1-\gamma)(w_s^s + w_s^a) + (1-\gamma)(1-\mu)f^p + \gamma h$
subject to

$$w_j^i \geq 0$$

$$w_s^s - c_f \geq w_n^s$$

$$\gamma q_1 w_h^s + (\gamma q_2 + \gamma q_3)w_s^s + (1-\gamma)w_s^s - c_f(\gamma q_3 + (1-\gamma)(1-\mu)) - c_m \geq w_n^s \qquad (\text{NE-C}_s)$$

$$q_1 w_h^a + (q_2 + q_3)w_s^a + z = w_s^a - (1-\mu)f^a \qquad (\text{NE-C}_a)$$

Observe that the first three terms at the RHS of NE-C$_s$ is also a part of the Principal's expected cost function. Re-arranging the NE-C$_s$ we obtain;

$$\gamma q_1 w_h^s + (1-\gamma q_1)w_s^s - c_f(\gamma q_3 + (1-\gamma)(1-\mu)) - c_m \geq w_n^s$$

We claim that $w_n^s = 0$ is optimal. To show this suppose that $w_n^s = \varepsilon$ where $\varepsilon > 0$. Then the constraints pertaining to the Supervisor become;

$$w_s^s \geq c_f + \varepsilon \qquad (1)$$

$$\gamma q_1 w_h^s + (1-\gamma q_1)w_s^s \geq c_f[\gamma q_3 + (1-\gamma)(1-\mu)] + c_m + \varepsilon \qquad (2)$$

An optimal wage structure must satisfy these two constraints,so it is obvious that whether (1) and/or (2) is binding or not, reducing ε towards zero violates neither (1) nor (2), and it can only reduce the Principal's cost by allowing for reduction in w_s^s and/or w_h^s. Thus, $w_n^s = 0$ is optimal.

Consider now, (1) and (2), where $w_n^s = 0$. We now claim that (2) must be binding, if (1) is not, i.e., when w_h^s and w_s^s are chosen optimally, (2) must hold with equality if $w_s^s > c_f$. Again, to show a contradiction, suppose that under the optimal wage structure (2) is not binding. The expected wage payments are:

$Z = \gamma q_1 w_s^h + (1-\gamma q_1)w_s^s > c_f[\gamma q_3 + (1-\gamma)(1-\mu)] + c_m > 0,$

where Z is the expected wage payments.

Then however, reducting w_h^s will reduce Z, contradicting the optimality of w_h^s. Thus (2) must be binding if $w_s^s > c_f$.

It is possible that under optimal wages NE-C$_s$ is not binding when $w_s^s = c_f$. In particular, if $c_m \leq c_f[\gamma q_2 + \mu(1-\gamma)], w_h^s = 0, w_s^s = c_f$ and $w_n^s = 0$ satisfies $w_s^s \geq c_f$ and makes NE-C$_s$ nonbinding. To see this subsititute these wages into NE-C$_s$ to get:

$(1-\gamma q_1)c_f \geq c_f[\gamma q_3 + (1-\gamma)(1-\mu)] + c_m$

Rearranging the terms yields, $c_f[\gamma q_2 + \mu(1-\gamma)] \geq c_m$.If this condition holds with strict inequality the Principal cannot reduce wages further by reducing w_h^s, w_s^s and w_n^s.

Thus, expected wage payments are as follows;

$$EW_s = c_f[\gamma q_3 + (1-\gamma)(1-\mu)] + c_m \qquad \text{(if } c_f(\gamma q_2 + \mu(1-\gamma)) \leq c_m\text{)}$$

$$EW_s = c_f(1-\gamma)q_1 \qquad \text{(if } c_f(\gamma q_2 + \mu(1-\gamma)) > c_m\text{)}$$

The Agent's optimal wages are,$w_h^a = 0$, $w_s^a = \dfrac{z + (1-\mu)f^a}{q_1}$.To see this, note that NE-C$_a$ can be written as,$\frac{z+(1-\mu)f^a}{q_1} = w_s^a - w_h^a$.

The minimal wages that satisfy this conditions are those stated above. Turning to the Principal's expected cost, the expected wage payments to the agent are:

$$EW_a = (z + (1-\mu)f^a)(\frac{1}{q_1} - \gamma)$$

The Principal's expected minimized cost will be as follows:

$$c_f[\gamma q_3 + (1-\gamma)(1-\mu)] + c_m + (z + (1-\mu)f^a)(\frac{1}{q_1} - \gamma) + (1-\gamma)(1-\mu)f^p + \gamma h \qquad \text{(III)}$$

Observe that the Principal's cost function is increasing in γ if $h+\mu+q_3c_f > (1-\mu)(f^a+f^p)+q_1c_f+z$ [2]

Under that condition the Principal will be better off as γ reduces towards zero. Note that, γ is the probability of agent being corrupt. Thus, γ reducing towards zero means that the Principal set up wages such that the Agent will choose to be non-corrupt. In that limit, Principal's cost will be as follows:

$$c_f(1-\mu)+c_m+\frac{1}{q_1}(z+(1-\mu)f^a)+(1-\mu)f^p$$

Otherwise if the above condition does not hold, the Principal's cost function is decreasing in γ. So the Principal will be better off by offering wage structures such that, under the monitoring Supervisor the Agent decides upon corruption.The Principal's cost in the limit when $\gamma \to 1$ is;

$$c_m+q_3c_f+(\frac{1-q_1}{q_1})(z+(1-\mu)f^a)+h$$

3.2.2 Inducing the Strategy Profile {Supervisor Monitors and Not Fabricates;Agent Randomizes}

In this case, we will characterize solutions in an enviroment where the Supervisor does not choose to fabricate evidence.The Principal's expected cost is stated as follows:

$$EC_p:$$
$$\gamma q_1(w_h^s+w_h^a)+\gamma q_2(w_s^s+w_s^a)+\gamma q_3(w_n^s+w_n^a)+(1-\gamma)\mu(w_s^s+w_s^a)+(1-\gamma)(1-\mu)(w_n^s+w_n^a)+\gamma h$$

Thus, the Principal's problem is:

$\min \gamma q_1(w_h^s+w_h^a)+\gamma q_2(w_s^s+w_s^a)+\gamma q_3(w_n^s+w_n^a)+(1-\gamma)\mu(w_s^s+w_s^a)+(1-\gamma)(1-\mu)(w_n^s+w_n^a)+\gamma h$

subject to

$$w_j^i \geq 0$$

[2]This observation can be done by taking partial derivative of the cost function with respect to γ, or any other parameter of interest.

$$w_n^s \geq w_s^s - c_f$$

$$\gamma q_1 w_h^s + \gamma q_2 w_s^s + \gamma q_3 w_n^s + (1-\gamma)\mu w_s^s + (1-\gamma)(1-\mu) w_n^s - c_m \geq w_n^s \tag{NE-C$_s$}$$

$$q_1 w_h^a + q_2 w_s^a + q_3 w_n^a + z = \mu w_s^s + (1-\mu) w_n^a \tag{NE-C$_a$}$$

As shown in subsection 3.2.1, $w_n^s = 0$ is optimal.

Next, we claim that the fabrication constraint is not binding in any solution to the Principal's problem. Thus, suppose that w_n^s and w_h^s are chosen optimally. Now,to establish a contradiction, suppose that the fabrication constraint is binding. The constrainst will be arranged as follows:

$$w_n^s = w_s^s - c_f \tag{3}$$

$$\gamma q_1 w_h^s + (\gamma q_2 + (1-\gamma)\mu) w_s^s \geq c_m \tag{4}$$

The optimal wages offered by the Principal to the Supervisor should satisfy the constraints (3) and (4) as well as the limited liability constraint. Observe that, setting $w_n^s = 0$, will result in setting $w_s^s = c_f$, which is the wage that makes the Supervisor indifferent between two strategies, fabricate and not fabricate. Assume that the Supervisor chooses the strategy which the Principal wants to induce. Now the expected wage payments are:

$$Z = \gamma q_1 w_h^s + (\gamma q_2 + (1-\gamma)\mu) c_f \geq c_m$$

From the remark we made earlier we assumed $c_f < c_m$, therefore we can conclude that reducing w_s^s towards zero will result in smaller expected wage payment without violating (4), but contradicting with the optimality of w_s^s. So, the fabrication constraint is not binding.

So, fabrication constraint becomes,

$$w_n^s > w_s^s - c_f$$

By far, we established that $w_n^s = 0$ is optimal. Under that wage scheme, setting $w_s^s = 0$ is optimal. Under the optimal wages, $w_n^s = 0$, $w_s^s = 0$, NE-C$_s$ becomes,

$$\gamma q_1 w_h^s \geq c_m \qquad \text{(NE-C}_s\text{)}$$

The Principal aims to minimize her expected cost, hence she prefers to offer the smallest w_h^s that satisfies NE-C$_s$. Setting $w_h^s = \frac{c_m}{\gamma q_1}$ is optimal.

To show this suppose that, $w_h^s = \frac{c_m}{\gamma q_1} + \varepsilon$ and $\varepsilon > 0$. NE-C$_s$ is still satisfied, however with strict inequality, and the expected wage payment becomes:

$$Z = \gamma q_1 \varepsilon + c_m \geq c_m$$

Note that, reducing w_h^s towards $\frac{c_m}{\gamma q_1}$ will result in smaller expected wage payment without violating NE-C$_s$, but contradicting with the optimality of w_h^s.

The optimal wage structure for the Supervisor, that satisfies all the constraints and minimize the expected disutility of the Principal is as follows: $W_s : (\frac{c_m}{\gamma q_1}, 0, 0)$.

Consider now the Agent's incentive scheme. Rearranging the NE-Ca will yield the following optimal wage structure for theAgent,$W_a = (0\ , 0, \frac{z}{1-\mu-q_3})$.

The Principal's expected minimized cost is:

$$c_m - \gamma z + +\gamma h + (1-\mu)\frac{z}{1-\mu-q_3} \qquad \text{(IV)}$$

Taking the partial derivative of (IV) with respect to the parameter, γ, we get: $h - z$

So, we can say that the Principal's cost function is increasing in γ (the probability of corruption) if the monetary equivalent of the harm done by corruption, h, to the Principal is higher than the monetary equivalent of benefit from corruption for the Agent, z.

It is natural to assume that $h > z$. Then the Agent should be induced not to choose corruption, as close to $\gamma = 0$ as possible to minimize the Principal's cost. It is intiutive to say that, when the harm done by the corruption is too high, then the Principal will take all the measures, i.e. set wages such that, to decrease the probability of the Agent being corrupt. She can set the wages such that γ will be arbitrarily close to zero, and in the limit the Principal's cost function will be:

$$c_m + (1-\mu)(\frac{z}{1-\mu-q_3})$$

On the other hand, in the unlikely case of $h < z$, $\gamma = 1$ will minimize the Principal's cost. Then the Principal's could simply not use the Supervisor and pay the Agent a flat wage.

We do not analyze the case where the Supervisor's strict preference is not to monitor, because in that case the Agent never randomizes and always chooses corruption.A pure strategy outcome that is not an equlibria occurs.

Next we will analyze the cases where the Agent has strict preferences whereas the Supervisor is indifferent.

3.2.3 Inducing the strategy profile {Supervisor Randomizes and Fabricates, Agent is Corrupt}

Next suppose that the Principal is interested in inducing an equilibrium in which Agent chooses corruption with probability one, and the Supervisor randomizes with a positive probability,p whether to monitor or not. In that case;

$$EC_p : pq_1(w_h^s + w_h^a) + (pq_2 + pq_3)(w_s^s + w_s^a) + (1-p)(w_n^s + w_n^a) + h$$

So, the Principal's problem is formulated as follows:

$\min pq_1(w_h^s + w_h^a) + (pq_2 + pq_3)(w_s^s + w_s^a) + (1-p)(w_n^s + w_n^a) + h$

subject to

$$w_j^i \geq 0$$

$$w_s^s - c_f \geq w_n^s$$

$$q_1 w_h^s + (pq_2 + pq_3)w_s^s - q_3 c_f - c_m = w_n^s \tag{NE-C$_s$}$$

$$pq_1 w_h^a + (pq_2 + pq_3)w_s^a + (1-p)w_n^a + z \geq pw_s^a - pf^a(1-\mu) + (1-p)w_n^a \tag{NE-C$_a$}$$

The optimal wage structure for the Agent should minimize the expected disutility of the Principal, as well as satisfying;

$$w_j^i \geq 0 \tag{5}$$

$$z + pf^a(1-\mu) \geq (p - pq_2 - pq_3)w_s^a - pq_1 w_h^a \tag{6}$$

To characterize the Agent's incentive scheme, rearranging NE-C$_a$ we will obtain:

$$z + pf^a(1-\mu) \geq (p - pq_2 - pq_3)w_s^a - pq_1 w_h^a \tag{NE-C$_a$}$$

We assumed that, it is natural to assume that, the monetary equivalent of benefit from corruption to the Agent, z, and the monetary equivalent of harm done by framing an honest agent as a corrupt one, f^a are strictly greater than zero. LLC coupled with the assumption that $z > 0$ and $f^a > 0$, the optimal incentive scheme for the Agent is:

$W^a = (0, 0, 0)$

Next, we characterize the optimal wage structure for the Supervisor. The characterization follows the steps adopted in the subsections 3.2.1 and 3.2.2.

$W_s = (\frac{c_m - q_2 c_f}{q_1}, c_f, 0)$

The Principal's expected cost function is:

$$pc_m + pq_3 c_f + h \tag{V}$$

Obviously, the cost function is increasing in the probability of the Supervisor monitoring. The Principal will be better off when the probabiliy of monitoring is arbitrarily close to zero, but not zero.

One can think the situation as such, the Principal aware of the fact that the Agent is corrupt, can offer the lowest wage possible to the Agent. So the Agent chooses to participate. Since being able to minimize the expected payment to the Agent by setting flat wages, without regarding the outcomes, the Principal will refrain from setting wages that will induce the Supervisor to monitor. The Principal simply chooses not to delegate her monitoring duty to the Supervisor. She simply does not prefer to monitor the Agent, who is corrupt with probability one. The Principal's cost function will be reduced to:

$$h$$

3.2.4 Inducing the Strategy Profile {Supervisor Randomizes and Not Fabricates,Agent is Corrupt}

The Principal's problem is as follows;

$\min pq_1(w_h^s + w_h^a) + pq_2(w_s^s + w_s^a) + pq_3(w_n^s + w_n^a) + (1-p)(w_n^s + w_n^a) + h$

subject to

$w_j^i \geq 0$

$w_n^s \geq w_s^s - c_f$

$q_1 w_h^s + q_2 w_s^s + q_3 w_n^s - c_m = w_n^s$

$pq_1 w_h^a + pq_2 w_s^a + pq_3 w_n^a + (1-p)w_n^a + z \geq p\mu w_s^a + p(1-\mu)w_n^a + (1-p)w_n^a$

The characterization of optimal incentive structure follows the steps we adopted in previous subsections. The optimal wage structures that minimizes the expected disutility and satisfies the constraints are;

$W_s = (\frac{c_m}{q_1}, 0, 0)$

$W_a = (0, 0, 0)$

The Principal's expected cost will be realized as;

$$pc_m + h \tag{VI}$$

The decision of not fabrication reduces the cost of the Principal, with respect to the previous case. However, note that there is no need to hire the Supervisor to perform monitoring when the Agent is one hundred percent corrupt. It is costly for the Principal to induce monitoring when monitoring does not change the Agent's decision to monitor.

We do not analyze the case where the Agent is not corrupt, because in that case best response of the Supervisor will be not to monitor, because monitoring will be costly for both the Supervisor and the Principal.

Last, we will analyze the cases where none of the players have strict preferences over the actions in their strategy set.

3.2.5 Inducing the strategy profile {Supervisor Randomizes and Fabricates, Agent Randomizes}

We now consider the case where both players are indifferent among their actions. The expected cost of the Principal can be written as;

$$EC_p : p\gamma q_1(w_h^s + w_h^a) + (p\gamma q_2 + p\gamma q_3)(w_s^s + w_s^a) + p(1-\gamma)(w_s^s + w_s^a) + (1-p)(w_n^s + w_n^a) + p(1-\gamma)(1-\mu)f^p + \gamma h$$

The Principal's problem is:

$\min p\gamma q_1(w_h^s + w_h^a) + (p\gamma q_2 + p\gamma q_3)(w_s^s + w_s^a) + p(1-\gamma)(w_s^s + w_s^a) + (1-p)(w_n^s + w_n^a) + p(1-\gamma)(1-\mu)f^p + \gamma h$

subject to

$$w_j^i \geq 0$$

$$w_s^s - c_f \geq w_n^s$$

$$\gamma q_1 w_h^s + (\gamma q_2 + \gamma q_3)w_s^s + (1-\gamma)w_s^s - \gamma q_3 c_f - (1-\gamma)(1-\mu)c_f - c_m = w_n^s \tag{NE-C$_s$}$$

$$pq_1 w_h^a + (pq_2 + pq_3)w_s^a + (1-p)w_n^a + z = pw_s^a + (1-p)w_n^a - p(1-\mu)f^a \tag{NE-C$_a$}$$

Observe that the first three terms at the RHS of NE-C$_s$ is also part of the the Principal's expected cost function. Re-arranging NE-C$_s$ we obtain;

$$\gamma q_1 w_h^s + (1-\gamma q_1)w_s^s - w_n^s = c_m + ((1-\gamma)(1-\mu) + \gamma q_3)c_f$$

The optimal wage for the Supervisor who reports no evidence is zero. To establish contradiction, suppose that $w_n^s = \varepsilon$ where $\varepsilon > 0$. Then the constraints pertaining to the Supervisor become;

$$w_s^s \geq c_f + \varepsilon \tag{7}$$

$$\gamma q_1 w_h^s + (1-\gamma q_1)w_s^s = c_m + ((1-\gamma)(1-\mu) + \gamma q_3)c_f + \varepsilon \tag{8}$$

An optimal wage structure should satisfy those two constraints, it is obvious that whether (7) is binding or not, reducing ε towards zero violates neither (7) nor (8) and it reduces the Principal's cost by allowing for reduction in w_s^s and/or w_h^s. Thus, $w_n^s = 0$ is optimal.

Consider now, (7) and (8), where $w_n^s = 0$. Now, we claim that (7) is binding and the optimal wage for the Supervisor who reports soft evidence is c_f. Suppose that (7) is not binding, fabrication constraint is reduced to;

$$w_s^s > c_f$$

Following the reduced fabrication constraint set $w_s^s = c_f + \varepsilon$, where $\varepsilon > 0$. Now the NE-C$_s$ becomes;

$$\gamma q_1 w_h^s + (1 - \gamma q_1)(c_f + \varepsilon) = c_m + ((1-\gamma)(1-\mu) + \gamma q_3)c_f$$

Observe that reducing w_s^s towards c_f decreases the expected cost function for the Principal. That contradicts with the optimality of w_s^s, thus the fabrication constraint is binding.

Next, rearranging NE-C$_s$ given that $w_n^s = 0$ and $w_s^s = c_f$, we have;

$$\gamma q_1 w_h^s = c_m + ((1-\gamma)(1-\mu) + \gamma q_3 - (1-\gamma q_1))c_f \text{ which can be written as}$$
$$\gamma q_1 w_h^s = c_m + (\gamma(\mu - q_2) - \mu))c_f$$

The optimal incentive scheme for the Supervisor is:
$W^s = (\dfrac{c_m + c_f(\gamma(\mu - q_2) - \mu)}{\gamma q_1}, c_f, 0)$
Now consider the Agent's incentive scheme, rearranging NE-C$_a$ we will obtain;

$$z + p(1-\mu)f^a = pq_1(w_s^a - w_h^a)$$

Observe that, the Agent's optimal incentive scheme can be written as:
$W^a = (0, \dfrac{z + p(1-\mu)f^a}{pq_1}, 0)$
Under the optimal wage structure, the expected cost function for the Principal will be:

$$pc_m + (z + p(1-\mu)f^a)(\frac{1}{q_1} - \gamma) + p(1-\gamma)(1-\mu)f^p + \gamma h + pc_f(\gamma\mu - \mu - \gamma(1-q_3) + 1) \quad \text{(VII)}$$

By tedious but simple partial derivation of the function with respect to the parameters p and γ, we observe that the function is increasing in p. On the other hand partial derivative with respect to γ will result in following expression;

$$h - (z + p\mu c_f + pq_2 c_f, + pq_1 c_f + p(1-\mu)f^a)$$

Once again, it is natural to assume that harm done by the corruption is much more than the expression $(z + p\mu c_f + pq_2 c_f, +pq_1 c_f + p(1-\mu)f^a)/$, hence the function is increasing in γ. In order to minimize her expected cost, the Principal must set wages such that the Agent is induced to be not corrupt, γ is arbitrarily close to zero but not equal to zero due to fact that agent being not corrupt is not an Nash equlibria. In the limit, where both the probabilities p and γ are arbitrarily close to zero, the Principal's cost function will be:

$$\frac{z}{q_1}$$

In the unlikely case of h being smaller than the expression $(z + p\mu c_f + pq_2 c_f, +pq_1 c_f + p(1-\mu)f^a$, then the cost function will be decreasing in γ. If this is the case, then the Agent is induced to be corrupt and the Supervisor is induced to choose not monitor. It is simply unnecessary for the Principal to monitor the Agent, she must offer flat wages to the Agent and must not hire the Supervisor at all.

3.2.6 Inducing the strategy profile {Supervisor Randomizes and Not Fabricates,Agent Randomizes}

In this last case, we will deal with the enviroment where the randomizing Supervisor will choose not to fabricate evidence when encountered no evidence.

The problem we are dealing with is as follows;

$\min p\gamma q_1(w_h^s + w_h^a) + p\gamma q_2(w_s^s + w_s^a) + p\gamma q_3(w_n^s + w_n^a) + p(1-\gamma)\mu(w_s^s + w_s^a) + p(1-\gamma)(1-\mu)(w_n^s + w_n^a) + (1-p)(w_n^s + w_n^a) + \gamma h$

subject to

$$w_j^i \geq 0$$

$$w_n^s \geq w_s^s - c_f$$

$$\gamma q_1 w_h^s + \gamma q_2 w_s^s + \gamma q_3 w_n^s + (1-\gamma)\mu w_s^s + (1-\gamma)(1-\mu) w_n^s - c_m = w_n^s \tag{NE-C$_s$}$$

$$pq_1 w_h^a + pq_2 w_s^a + pq_3 w_n^a + (1-p) w_n^a + z = p\mu w_s^a + p(1-\mu) w_n^a + (1-p) w_n^a \tag{NE-C$_a$}$$

The characterizations of the incentive scheme for the Supervisor and the Agent are following the steps we have adopted in subsection 3.2.5. Using the methods adopted, the optimal wage structure is:

$W_s : (\frac{c_m}{\gamma q_1}, 0, 0)$

$W_a : (0, 0, \frac{z}{p(1-\mu-q_3)})$

Under the optimal wage structure,the Principal's expected cost function will be as follows:

$$pc_m + \gamma h + (\frac{1}{p} - \mu)\frac{z}{1-\mu-q_3} - \gamma z \tag{VIII}$$

Now, first take the partial derivative of the cost function with respect to the parameter, p. The resulting expression will be:

$$c_m - \frac{z}{p^2(1-\mu-q_3)}$$

Under the condition that $\mu + q_3$ is greater than 1 then the cost function is said to be increasing in p. In other words, if the probability of reaching soft evidence when the Agent is honest added to the probability of reaching no evidence when the Agent is corrupt is greater than 1, then the function is increasing probabilty of monitoring. That is plausible because that means that the probabilitys of reaching no evidence when agent is corrupt and reaching soft evidence when the Agent is honest is relatively high than theri counterparts. In either of the case, a montioring Supervisor will be costly to the Principal, so she prefers to induce a strategy where the Supervisor is induced to monitor with a probabilty p, as close to zero as possible.

Otherwise, if $1 - \mu - q_3$ is positive, we can conclude that the cost function is decreasing in p. That is to say, reaching no evidence in case of corruption and soft evidence in case of honesty is smaller with respect to the previous condition. The Principal may be willing to induce the outcome where the Supervisor monitors with expectation that the Supervisor can be able to report corruption with high or soft evidence.

Taking the partial derivative of (VII) with respect to the parameter, γ, we get: $h - z$

So, we can say that the Principal's cost function is increasing in γ (the probability of corruption) if the monetary equivalent of the harm done by corruption, h, to the Principal is higher than the monetary equivalent of benefit from corruption for the Agent, z.

It is natural to assume that $h > z$. Then the Agent should be induced not to choose corruption, as close to $\gamma = 0$ as possible to minimize the Principal's cost. It is intiutive to say that, when the harm done by the corruption is too high, then the Principal will take all the measures, i.e. set wages such that, to decrease the probability of the Agent being corrupt.

The analysis in the absence of collusion concludes that the equlibria in which the Agent is corrupt with probabality one is not interesting for our research question. In those cases, the Principal is simply better off by extracting the Supervisor from the game and offering flat wages to the Agent whom she knows is corrupt. Introducing monitoring and the Supervisor to the model in those cases only achieves to increase the expected cost of the Principal.

The Principal is wiling to induce the strategies where either the Agent or both of the players randomize. The equlibria and their related cost functions are as follows:

- {Monitor, Not Fabricate, Randomize)

$$c_m + \gamma h - \gamma z + (1-\mu)\frac{z}{1-\mu-q_3} \tag{IV}$$

- {Randomize,Not Fabricate,Randomize}

$$pc_m + \gamma h - \gamma z + (\frac{1}{p}-\mu)\frac{z}{1-\mu-q_3} \tag{VIII}$$

Observe that as p approaches to 1, (VII) comes closer to the (IV). Under the assumption that $1-\mu-q_3$ is strictly positive and the probability of monitoring is arbitrarily close to 1,the Principal is willing to induce the equlibrium {Randomize,Not Fabricate, Randomize} if $(1-p)c_m$ is greater than the the expression $(1-\frac{1}{p})\frac{z}{1-\mu-q_3}$. Observe that, p being arbitrarily close to 1 decreases the cost function by reducing c_m. On the other hand $\frac{1}{p}$ is greater than 1, this amplifies the expression $\frac{z}{1-\mu-q_3}$ with respect to (IV). So if the effect of decreasing the c_m by setting the wages that induces the Supervisor to monitor, with probability p is more than the effect of amplifying the expression $\frac{z}{1-\mu-q_3}$, then the Principal prefers (VIII) over (IV).

Now consider the case where p is arbitrarily close to zero, again under the assumption that $1-\mu-q_3$ is strictly positive. The cost function (IV) is smaller than the cost function (VIII). Although, c_m becomes insignificiant as p approaches to zero in the cost function

$(1-\mu-q_3$ is strictly positive (VIII), the expression $(\frac{1}{p}-\mu)\frac{z}{1-\mu-q_3}$ skyrocketed to infinity because in the limit $\frac{1}{p}$ converges to infinity as p approaches to zero.

If $1-\mu-q_3$ is strictly negative, since $0<1<p$ in the latter equlibria, we can coclude that $\frac{1}{p}>1$ always. Couple that information with the fact that $(\frac{1}{p}-\mu)\frac{z}{1-\mu-q_3}$ has a negative sign, then (VIII) is always smaller than (IV). The Principal prefers to induce equlibrium {Randomize,Not Fabricate,Not Fabricate}.

All along the analysis, the Principal's problem has been to minimize her expected disutility function subject to the constraints structured by the enviroment. All the cases we have analyzed have been finalized with different cost functions to the Principal. In the cases where one of the players have strict preferences over their actions and the other is randomizing, we conclude that the minimum cost function is achieved when the Supervisor is not fabricating. Likewise, when both players are randomizing, the Principal will prefer to induce the equilibria where the Supervisor chooses not to fabricate. Inducing fabrication will definitely increase cost function, due to fabrication constraint, at least by c_f for the Supervisor. On the other hand, the introduction of the fabrication will result in the high probability of soft evidence realization and soft evidence wages will be paid more likely. So with this information, the Agent who is indifferent between corruption and honesty is expected to choose honesty. However, with the optimal incentive schemes we have characterized, the Agent will decide upon corruption. When the Agent decides upon honesty when fabrication is induced by the Principal, he will bear the cost of framing,f^a. So, the Principal have to make sure that the difference between expected payoff, under fabrication, from corruption and no evidence wage in case of honesty at least as much as the cost of framing,f^a. The wages we have characterized do not satisfy that condition. The Agent is better off when he decides upon corruption if the Principal is fabricating. There does not exist any cost associated with framing of a corrupt agent. Also, the cost function is not increased only by c_f, but by the framing cost inflicted upon the Principal, f^p.

Let us demonstrate our point by comparing the cost functions related to the fabrication and not fabrication in the equlibria we have analyzed above.

- {Monitor, Not Fabricate, Randomize)

$$c_m+\gamma h-\gamma z+(1-\mu)\frac{z}{1-\mu-q_3} \tag{IV}$$

Let us digress that cost function, first we will look at the expected wage payment to the Supervisor

$$EW_s = c_m$$

Next, the expected wage payment to the Agent

$$EW_a = (1-\mu)\frac{z}{1-\mu-q_3} - \gamma z$$

- {Monitor,Fabricate, Randomize)

$$c_f[\gamma q_3 + (1-\gamma)(1-\mu)] + c_m + (z + (1-\mu)f^a)(\frac{1}{q_1} - \gamma) + (1-\gamma)(1-\mu)f^p + \gamma h \quad \text{(III)}$$

Let us digress that cost function, first we will look at the expected wage payment to the Supervisor

$$EW_s = c_f[\gamma q_3 + (1-\gamma)(1-\mu)] + c_m$$

Next, the expected wage payment to the Agent

$$EW_a = (z + (1-\mu)f^a)(\frac{1}{q_1} - \gamma)$$

- {Randomize,Not Fabricate,Randomize}

$$pc_m + \gamma h - \gamma z + (\frac{1}{p} - \mu)\frac{z}{1-\mu-q_3} \quad \text{(VIII)}$$

Let us digress that cost function, first we will look at the expected wage payment to the Supervisor

$$EW_s = pc_m$$

Next, the expected wage payment to the Agent

$$EW_a = (\frac{1}{p} - \mu)\frac{z}{1-\mu-q_3} - \gamma z$$

- {Randomize,Fabricate,Randomize}

$$pc_m + (z + p(1-\mu)f^a)(\frac{1}{q_1} - \gamma) + p(1-\gamma)(1-\mu)f^p + \gamma h + pc_f(\gamma\mu - \mu - \gamma(1-q_3) + 1) \quad \text{(VII)}$$

Let us digress that cost function, first we will look at the expected wage payment to the Supervisor

$$EW_s = pc_m + p((1-\gamma q_1) + (\gamma(\mu - q_2) - \mu)c_f$$

Next, the expected wage payment to the Agent

$$EW_a = (z + (1-\mu)f^a)(\frac{1}{q_1} - \gamma)$$

It is obvious that the expected cost functions pertaining to fabrication cases is higher than that of pertainig to no fabrication cases.

Observe that, the results are not robust. They are solely dependent on our construction of the costs and rewards.First, we have assumed that fabrication is something costly and then we have assumed that cost of framing is only inflicted when the Agent is honest.

4 The Analysis in The Existence of Collusion

4.1 The Ex-Post Collusion Analysis

Ex-post collusion is an agreement between the agent and the supervisor upon realization of an outcome of the game, whereby the two parties find a mutually beneficial swtich to a different outcome, upsetting the Principal's objective. This agreement involves transfers between the parties.

That is to say,when the monitoring occurs and the outcome is realized, if the Supervisor reports the outcome, the Principal will pay the wages offered at the beginning of the game. If the Agent persuades the Principal not to reveal the evidence, then they will both receive the no evidence wage. That kind of agreement only occurs if there exists a positive surplus that can be gained through the agreement.

The modelling of ex-post collusion is as follows: After the last stage of the game, the Supervisor observes outcomes. The Agent, if corrupt, offers a bribe to the Supervisor not to reveal the information to the Principal. In the thesis, we will not deal with the bargaining game to determine the bribe, but assume if there is exists a surplus from collusion, collusion occurs. In the collusion literature, ex-post collusion is characterized whether to report the outcome or not. However, in our case ex-post collusion can be either not reporting hard evidence or soft evidence. We do not consider a collusion that incorporates the reporting hard evidence as soft evidence. Since, hard evidence is defined to be the proof of corruption, we assume that the Supervisor cannot reveal it as something less in comparison.

To prevent ex-post collusion, the Principal has to make sure that the sum expected payoff from reporting the "true" evidence is at least as large as the payoffs from reporting no evidence. That is called *collusion proofness constrant.* We will characterize the optimal collusion proof incentive schemes for the equilibrium we have found in non-cooperative game above.

Proposition 2 *The incentive scheme offered by the Principal,in the {Monitor,Not Fabricate,Randomize} equilibrium is not ex-post collusion proof.*

To prove the proposition above, let us write the Principal's problem pertaining to the equilibriium once again.

$\min \gamma q_1(w_h^s + w_h^a) + \gamma q_2(w_s^s + w_s^a) + \gamma q_3(w_n^s + w_n^a) + (1-\gamma)\mu(w_s^s + w_s^a) + (1-\gamma)(1-\mu)(w_n^s + w_n^a) + \gamma h$

subject to

$$w_j^i \geq 0$$

$$w_n^s \geq w_s^s - c_f$$

$$\gamma q_1 w_h^s + \gamma q_2 w_s^s + \gamma q_3 w_n^s + (1-\gamma)\mu w_s^s + (1-\gamma)(1-\mu)w_n^s - c_m \geq w_n^s \qquad \text{(NE-C}_s\text{)}$$

$$q_1 w_h^a + q_2 w_s^a + q_3 w_n^a + z = \mu w_s^s + (1-\mu)w_n^a \qquad \text{(NE-C}_a\text{)}$$

$$w_h^s + w_h^a \geq w_n^s + w_n^a \qquad \text{(Collusion Proofness for Hard Evidence)}$$

$$w_s^s + w_s^a \geq w_n^s + w_n^a \qquad \text{(Collusion Proofness for Soft Evidence)}$$

The incentive schemes obtained in the non-cooperative Nash Equlibrium is as follows: $W^s = (\frac{c_m}{\gamma q_1}, 0, 0)$ and $W^a = (0, 0, \frac{z}{1-\mu-q_3})$

Observe that, the incentive schemes of the non-cooperative Nash Equlibrium do not satisfy the collusion proofness for soft evidence constraint. Not reporting soft evidence is profitable for the Supervisor and the Agent because there exists a surplus from collusion.

To characterize the collusion proof incentive scheme for the equilibrium, rearrange NE-C$_a$ to obtain:

$$z = (\mu - q_2)w_s^s + (1 - \mu - q_3)w_n^a - q_1 w_h^a$$

We claim that, $w_h^a = 0$ is optimal. To show that, suppose $w_h^a = \varepsilon$ and $\varepsilon > 0$, then NE-C$_a$ becomes

$$z + q_1\varepsilon = (\mu - q_2)w_s^s + (1 - \mu - q_3)w_n^a$$

This will result in higher w_s^a and/or w_n^a wages and increases the expected cost functio of the Principal. So, reducing w_h^a to zero is optimal.

Now, given that $w_h^a = 0$, NE-Ca becomes;

$$z = (\mu - q_2)w_s^s + (1 - \mu - q_3)w_n^a$$

Observe that, we need to make sure that the sum expected payoff from reporting soft evidence is at least as large as reporting no evidence. So setting $w_n^a = 0$ and $w_s^a = \frac{z}{\mu - q_2}$ is optimal collusion proof incentive scheme. Note that, the solution is not unique you can increase w_n^a by ε and decrease w_s^a by $\frac{\varepsilon}{\mu - q_2}$ unless you violate the collusion proofness for soft evidence constraint.

So the collusion proof incentive schemes are; $W^s = (\frac{c_m}{\gamma q_1}, 0, 0)$ and $W^a = (0, \frac{z}{\mu - q_2}, 0)$.

The cost function associated with that cooperative equilibria is:

$$c_m - \gamma z + \mu \frac{z}{\mu - q_2} + \gamma h$$

Proposition 3 *The incentive scheme offered by the Principal,in the {Randomize,Not Fabricate,Randomize} equilibrium is not ex-post collusion proof. The ex-post collusion proof scheme is;* $W^s = (\frac{c_m}{\gamma q_1}, 0, 0)$ *and* $W^a = (0, \frac{z}{p(\mu - q_2)}, 0)$.

The proof to that proposition follows the proof we have done in Proposition 2.

The cost function for the cooperative equlibria is:

$$pc_m - \gamma z + \mu \frac{z}{\mu - q_2} + \gamma h$$

Notice that to prevent collusion the Principal has to make sure that no additional surpluses can be created by switching from one stratgey to the other. Although we are not analyzing the bargaining game between the Supervisor and the Agent,it is obvious that ex-post collusion proof incentive schemes provide no room for extra surpluses that can be divided among the players.

4.2 Ex-Ante Collusion

In that section we will analyze whether to incentive schemes we have characterized for the ex-post collusion proofness can prevent ex-ante collusion Ex-ante collusion is an agreement where the Supervisor chooses not to monitor the Agent in return for a "transfer" from the Agent, as well as leaving the ex-post collusion possibilities that can occur in case of monitoring.

The modelling of ex-ante collusion is as follows: At the beginning of the game, the Agent offfers a bribe to the Supervisor to persuade him not to monitor. If the Supervisor accepts the bribe, he chooses not to monitor and both of the player's receive no evidence wage.

To prevent ex-ante collusion the Principal has to make sure that the sum of expected payoffs from monitoring and reporting the "true" evidence is at least as large as the sum of expected payoffs from not monitoring. We will characterize the ex-ante collusion proof incentive schemes for the non-cooperative game above.

Proposition 4 *The incentive scheme that satisfies the ex-post collusion proofness is ex-ante collusion proof.*

First we will look at the case,{Monitor, Not Fabricate, Randomize} equilibrium, assuming ex-post collusion proofness is satisfied, the Principal's problem can be writtten as follows;

$\min \gamma q_1(w_h^s+w_h^a)+\gamma q_2(w_s^s+w_s^a)+\gamma q_3(w_n^s+w_n^a)+(1-\gamma)\mu(w_s^s+w_s^a)+(1-\gamma)(1-\mu)(w_n^s+w_n^a)+\gamma h$

subject to

$$w_j^i \geq 0$$

$$w_n^s \geq w_s^s - c_f$$

$$\gamma q_1 w_h^s + \gamma q_2 w_s^s + \gamma q_3 w_n^s + (1-\gamma)\mu w_s^s + (1-\gamma)(1-\mu) w_n^s - c_m \geq w_n^s \tag{NE-C$_s$}$$

$$q_1 w_h^a + q_2 w_s^a + q_3 w_n^a + z = \mu w_s^s + (1-\mu) w_n^a \tag{NE-C$_a$}$$

$$\gamma q_1(w_h^s+w_h^a)+\gamma q_2(w_s^s+w_s^a)+(1-\gamma)\mu(w_s^s+w_s^a)+\gamma q_3(w_n^s+w_n^a)+(1-\gamma)(1-\mu)(w_n^s+w_n^a)-c_m \geq w_n^s+w_n^a \tag{Ex-Ante Collusion Proofness}$$

The ex-post collusion proof incentive scheme is; $W^s = (\frac{c_m}{\gamma q_1}, 0, 0)$ and $W^a = (0, \frac{z}{\mu - q_2}, 0)$. Let us plug the wages into the ex-ante collusion proofness constraint. The reulting expression is;

$\frac{z}{\mu - q_2}(\gamma q_2 + (1-\gamma)\mu) \geq 0.$

So we can claim that the ex-post collusion proof incentive scheme satisfies the ex-ante collusion for this equilibrium.

Next, consider the {Randomize, Not Fabricate, Randomize} equilibrium, assuming ex-post collusion proofness is satisfied, the Principal's problem can be writtten as follows;

$\min p\gamma q_1(w_h^s+w_h^a)+p\gamma q_2(w_s^s+w_s^a)+p\gamma q_3(w_n^s+w_n^a)+p(1-\gamma)\mu(w_s^s+w_s^a)+p(1-\gamma)(1-\mu)(w_n^s+w_n^a)+(1-p)(w_n^s+w_n^a)+\gamma h$

subject to

$$w_j^i \geq 0$$

$$w_n^s \geq w_s^s - c_f$$

$$\gamma q_1 w_h^s + \gamma q_2 w_s^s + \gamma q_3 w_n^s + (1-\gamma)\mu w_s^s + (1-\gamma)(1-\mu) w_n^s - c_m = w_n^s \tag{NE-C$_s$}$$

$$p q_1 w_h^a + p q_2 w_s^a + p q_3 w_n^a + (1-p) w_n^a + z = p\mu w_s^a + p(1-\mu) w_n^a + (1-p) w_n^a \tag{NE-C$_a$}$$

$$p\gamma q_1(w_h^s+w_h^a)+p\gamma q_2(w_s^s+w_s^a)+p(1-\gamma)\mu(w_s^s+w_s^a)+p\gamma q_3(w_n^s+w_n^a)+p(1-\gamma)(1-\mu)(w_n^s+w_n^a)+(1-p)(w_n^s+w_n^a)- \tag{Ex-Ante CP}$$

Insert the ex-post collusion proof incentive scheme, $W^s = (\frac{c_m}{\gamma q_1}, 0, 0)$ and $W^a = (0, \frac{z}{(\mu - q_2)}, 0)$, and check for the ex-ante collusion proofness. The resulting expression is;

$$\frac{z}{(\mu - q_2)}(p\gamma q_2 + p(1-\gamma)\mu \geq 0$$

Next we will look at the case, where {Randomize, Not Fabricate, Randomize} is the equilibrium, assuming ex-post collusion proofness is satisfied, the Principal's problem can be writtten as follows;

$\min p\gamma q_1(w_h^s + w_h^a) + p\gamma q_2(w_s^s + w_s^a) + p\gamma q_3(w_n^s + w_n^a) + p(1-\gamma)\mu(w_s^s + w_s^a) + p(1-\gamma)(1-\mu)(w_n^s + w_n^a) + (1-p)(w_n^s + w_n^a) + \gamma h$

subject to

$$w_j^i \geq 0$$

$$w_n^s \geq w_s^s - c_f$$

$$\gamma q_1 w_h^s + \gamma q_2 w_s^s + \gamma q_3 w_n^s + (1-\gamma)\mu w_s^s + (1-\gamma)(1-\mu) w_n^s - c_m = w_n^s \tag{NE-C$_s$}$$

$$p q_1 w_h^a + p q_2 w_s^a + p q_3 w_n^a + (1-p) w_n^a + z = p\mu w_s^a + p(1-\mu) w_n^a + (1-p) w_n^a \tag{NE-C$_a$}$$

$$p\gamma q_1(w_h^s+w_h^a)+p\gamma q_2(w_s^s+w_s^a)+p(1-\gamma)\mu(w_s^s+w_s^a)+p\gamma q_3(w_n^s+w_n^a)+p(1-\gamma)(1-\mu)(w_n^s+w_n^a)+(1-p)(w_n^s+w_n^a)- \tag{Ex-Ante CP}$$

Insert the ex-post collusion proof incentive scheme, $W^s = (\frac{c_m}{\gamma q_1}, 0, 0)$ and $W^a = (0, \frac{z}{p(\mu - q_2)}, 0)$, and check for the ex-ante collusion proofness. The resulting expression is;

$$\frac{z}{(\mu - q_2)}(\gamma q_2 + (1-\gamma)\mu) \geq 0$$

The intuition behind the result is as follows, by preventing ex-post collusion we make sure that the sum of expected payoffs from reporting any evidence is as least as large as reporting no evidence. Since, in our framework, reporting no evidence and not monitoring leads to the same no evidence wage and the wages we offer compensate for the monitoring cost, ex-ante collusion can be prevented with ex-post collusion proof incentive schemes.

5 Concluding Remarks

This thesis incorporates the incentive schemes offered in order to prevent corruption in a three layer hierarchy. The thesis also characterizes the optimal incentive schemes in an enviroment where fabrication of evidence, only soft evidence, is possible. While doing so, we have assumed that a costly monitoring and fabrication technology is adopted. In section 3, we have started with analyzing the pure strategy Nash Equlibria. We have concluded that the Principal will be better off when she offers the incentive scheme which induces "Monitor, Corrupt and Not Fabricate" strategies.

Then we continue with analyzing the mixed strategy Nash Equlibria. This analysis also concludes that the Principal is better off when the Supervisor decides not to fabricate. The result which is contradictory to our intiution is due to the fact that fabrication is a costly technology, framing of an honest agent will inflict cost both on the Agent and the Principal. Also, analysis shows that the Principal can offer flat wages to the Agent when the Supervisor chooses to monitor. That is to say, if there is a positive probability that the Supervisor will monitor and the Agent is corrupt, the Principal can offer the smallest wage that satisfy all the constraint to the Agent. That is due to the fact that, there is a strictly positive private benefit gained from corruption by the Agent.

In section 4, we analyze the cooperative Nash Equlibria. We start the analysis to check whether the optimal incentive schemes we have characterized in the previous section is ex-post collusion proof or not. The section conludes that the equlibria, {Monitor, Not Fabricate and Corrupt} and {Randomize,Not Fabricate and Corrupt}are ex-post collusion proof. While on the other hand {Monitor,Not Fabricate and Randomize} and {Randomize, Not Fabricate and Randomize}are not ex-post collusion proof. After we have characterized the ex-post collusion proof incentive schemes for that equlibria, we analyze the ex-ante collusion proofness. The thesis concludes that, given that ex-post collusion proofness is satisfied, ex-ante collusion can be prevented.

We recommend that, fabrication costs, harms and constraints can be redefined to characterize the incentive schemes in upcoming research in the area.

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