ON THE HIDDEN COSTS OF MONITORING CORRUPTION OR EFFORT

Jana Krajčová

CERGE-EI

Charles University
Center for Economic Research and Graduate Education
Academy of Sciences of the Czech Republic
Economics Institute

WORKING PAPER SERIES (ISSN 1211-3298)
Electronic Version

404

Working Paper Series **404**
(ISSN 1211-3298)

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Prague, January 2010

ISBN 978-80-7343-207-2 (Univerzita Karlova. Centrum pro ekonomický výzkum a doktorské studium)
ISBN 978-80-7344-196-8 (Národohospodářský ústav AV ČR, v.v.i.)

On the Hidden Costs of Monitoring Corruption or Effort*

Jana Krajčová
CERGE–EI†

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Abstract

In this paper, I analyze the effects of monitoring on an agent's incentives in a two-period principal-agent model in which the agent decides on his effort and corruptibility. The agent's type and strategy are unknown to the principal. I compare incentive-compatible wages under three different scenarios: when the principal does not monitor and only observes output; when she monitors the agent's effort choice; and when she monitors the agent's corruptibility. I find that monitoring of effort improves the sorting of types but it might also give the agent more incentive to be corrupt. Monitoring of corruption does not improve the sorting of types but it negatively affects the agent's incentive to be corrupt.

Abstrakt

V tomto článku skúmam možný dopad monitorovania na agentovu "motiváciu" v dvojperiódovom modeli typu "principál-agent," v ktorom agent robí rozhodnutia o vynakladanom úsilí a o svojej uplatiteľnosti. Principál nepozná typ agenta ani jeho zvolenú stratégiu. Porovnávam mzdy nevyhnutné pre motiváciu agenta v troch rôznych situáciach: keď principál nemonitoruje agenta a teda pozná iba jeho konečnú produkciu, keď principál monitoruje agentovu voľbu úsilia a keď pricipál monitoruje agentovu uplatiteľnost'. Zistila som, že monitorovanie úsilia umožňuje principálovi lepšie triedenie typov (agenta), ale zároveň agent je viac náchylný ku korupcii. Naopak monitorovanie uplatiteľnosti nezlepšuje triedenie typov, avšak negatívne ovplyvňuje pohnútky na korupciu.

Keywords: corruption, monitoring, contract, incentive-compatibility
JEL classification: D73,D86,K42

*I would like to thank Andreas Ortmann, Marco Celentani, and Peter Katuscak who kept giving me valuable comments and suggestions along the way and thereby helped to shape this paper.

†Center for Economic Research and Graduate Education–Economics Institute, a joint workplace of Charles University in Prague and the Academy of Sciences of the Czech Republic. Address: CERGE–EI, P.O. Box 882, Politických vězňů 7, Prague 1, 111 21, Czech Republic.

1 Introduction

It has been shown in the career concerns literature that the principal's monitoring might harm the agent's incentives (see e.g. Cremer 1995; Holmström 1999; Dewatripont, Jewitt, and Tirole 1999; Prat 2005): if the agent's ability is unknown and his effort cannot be perfectly observed by the principal, the agent might have an incentive to put in more effort in order to signal high ability. Once the principal starts to observe the agent's ability, this incentive disappears.

Similarly, the literature on intrinsic motivation suggests that monitoring, as a display of distrust, is likely to be detrimental to the agent's intrinsic motivation and his dedication to the job (e.g., Kreps 1997 and Benabou and Tirole 2003).

Monitoring thus might not necessarily lead to improved performance of the agent and in some situations the principal might be better off not monitoring.

The present research is motivated by a recent discussion in the Czech Republic. To fight corruption, law enforcement authorities discussed installing cameras and GPS systems into police cars in order to monitor traffic police officers on duty. Leaving aside the question whether such monitoring systems can be effective, an important question is whether they might negatively affect officers' incentives. Some officers, especially those who are honest, may be offended and reduce effort in retaliation (the intrinsic motivation argument); others' incentives to signal high quality may be affected (the career concerns argument). Some officers may simply believe that as long as they are honest, they do not need to work hard because the principal values honesty more than effort. One way or another, the principal may face reduced incentives on the part of the agent to put in effort. In addition, the effect of monitoring systems on individual corruption decisions is in question.

The decision to be corrupt results from officers' attitudes towards corruption, which might be based on their home-grown moral scruples, the perception of attitudes towards corruption in their social context, the perception of risks connected

to corrupt behavior, etc. Consequently, some people may be more prone to corruption than others. In the literature this is modelled as the psychic cost of corruption (see, for example, Celentani and Ganuza 2002, or Cule and Fulton 2005). The actual decision to take (or ask for) a bribe then also depends on the value of the bribe. We say that people who are conditionally susceptible to taking (or asking for) a bribe are opportunistic. When talking about petty police corruption, it is likely that some fraction of people are honest because their psychic cost of corruption is too high to outweigh (relatively low) potential monetary gains.[1]

An authority, or the principal, evaluating the work of police officers, might, in general, observe no more than their daily output which, for example for traffic police, might be measured by the total value of issued tickets. How much an officer collects in fines, however, depends on several factors: the effort he is exerting and his corruptibility, but also on the number of misbehaving drivers in his area or other exogenous factors. Therefore, an officer who collects few fines may not necessarily be corrupt or shirking. Thus, the observed "output" gives the principal only limited information about the actual behavior of the officer and the incentive-compatibility design of a reward and punishment system becomes an issue.

Assume that the principal wants to induce a high level of effort and non-corruptibility. The question I ask is whether, and at what price, the principal can influence the incentives of officers in the desired way by monitoring them and thereby acquiring additional information about their type and/or their action choices.

I examine the effect of the imperfect partial monitoring of an agent (traffic police officer) who has two binary decision margins: (1) unobservable effort (diligence and time spent pursuing misbehaving drivers); and (2) an unobservable decision

[1] Aleš Pachmann, who was associated with the Police Academy of the Czech Republic, suggested in private communication that surveys on police corruption suggest about 10% of police officers being unconditionally honest.

about how much of the produced output to extract for himself (how many of the violations to fine officially and how many to "fine" in the form of a bribe). Hence the model captures an element of hidden action (effort) with an element of hidden information (the output before any potential extraction). On top of that, there is another source of hidden information in that the agent may be intrinsically honest (will never extract any rents) or opportunistic (will extract rents under the right economic incentives). However, the type is not known before signing the contract and hence this is just another layer of hidden information rather than an element of adverse selection.

I study and compare three monitoring technologies: (1) No Monitoring, (2) Monitoring of Corruption, and (3) Monitoring of Effort. If the principal does not monitor she can only observe output that the agent produces. If the principal monitors, the monitoring is partial in that only one decision margin is monitored and it is imperfect in that the probability of detecting a lack of effort or corruptibility is less than one. I am interested in the effects of monitoring on both agent's effort choice and his corruptibility.

The police officers thus affect the quality of enforcement they are expected to provide by deciding on the effort and their corruptibility. These two decisions are not completely independent, though. On the one hand, putting in more effort generates a higher expected output (catching more violating drivers), which gives the agent more opportunities for rent extraction. On the other hand, planning to extract a certain fraction of the rent gives the agent more incentives to exert effort. This generates two key differences from the career concerns literature, where the result is driven by a certain substituability between the *exogenous* ability of the agent and the *endogenous* effort decision. First, in the present model, even though the propensity to corruption is exogenously given to the agent, the actual decision to take bribes is endogenous and therefore it may respond to economic incentives

(whereas ability in the career concerns literature is out of the agent's control). Second, the interplay of effort choice and corruptibility is more complicated than in the career concerns literature: high effort increases the probability of high produced output (before any rent extraction) but, at the same time, it creates more opportunities for bribery and thereby might reduce observed output (after any rent extraction). Effort choice and corruptibility are not substitutes. Consequently, the monitoring is likely to affect the incentives in a somewhat different way than in the career concerns literature. In fact, any effect of monitoring on one decision margin may "spill over" to the other margin as well, which is one of the interesting properties of the model.

The punishment for low effort or rent extraction is the termination of the contract with the agent. Since at least two periods are necessary to make monitoring and its consequences for future payoffs an important part of the incentives package, I construct a two-period principal-agent model in which a principal offers a two-period contract to an agent of unknown type. In the contract, the principal commits herself to a monitoring technology and to wages to be paid to the agent at the end of the employment. The principal decides, at the end of the first period, based on her monitoring, whether she will keep her current employee or fire him and hire a new one for the second period. I assume that the principal is also ex-post exogenously committed to monitoring and to the firing rule specified in the contract. Monitoring is costless.

I define the agent's type as his predisposition (or propensity) to corruption. I assume that whether an agent with a given predisposition to corruption takes a bribe in a given period is a decision that he takes in response to the reward and punishment system that is in place. To simplify the analysis, I assume that there are two types of agents in the population: an honest type, with zero utility from corruption, and a corrupt type, with some positive utility from corruption.

I assume that before signing the contract the agent does not know his type.[2] I make this assumption to avoid adverse selection, which would make the agent's strategy space richer and thereby the analysis more complicated. Agents discover their types quickly, though. Imagine, for example, a new officer who has no prior experience either with this kind of a job or with bribery as such. It is likely to take him only a few transactions to find out what his "price" is, or whether there is any price at all. To simplify the analysis, I assume that the agent learns his type the very same moment when he starts the job. Thus when choosing the effort level, he already makes an informed decision.

In order to model the exogenous factors mentioned above that make it impossible for the principal to distinguish the types solely based on the output realization, I assume that luck will affect the output of both types of agent. Imagine days with high traffic and lots of speeding drivers (may be caused by good road conditions) and days when people drive more in compliance with law (may be caused by poor visibility or other poor road conditions). In order to keep things as simple as possible, I assume that luck comes into play only when the agent is exerting a high level of effort.

I assume that two levels of output are possible: low or high. Only a hard-working and lucky agent produces high output and can extract for himself through bribes that part of output that is above the output resulting from low effort.[3] This brings about an interesting conflict on the side of the principal: on the one hand, she prefers high effort as it increases the likelihood of high output yet, on the other hand, high effort implies also more opportunities for opportunistic agents to collect bribes. It is therefore not clear whether it is in the principal's best interest to

[2]In reality, he might have some at least imperfect knowledge but I will abstract from that for simplicity. The adverse selection case might be an interesting extension of the model.

[3]Producing low output and then, in addition, extracting some part of it for himself would automatically reveal the agent's type to the principal and hence eliminate any chance of second-period profits.

automatically induce a high level of effort.

In general, the principal might have different preferences about the agent's actions. In real-life scenarios, the principal might put more weight on how much effort the agent puts in, or, alternatively, non-corruptibility might be a top priority for her. As for the former, imagine the example of traffic police. Even an opportunistic officer, who is working really hard in order to create more opportunities for corruption, might produce some, though a smaller, deterrence effect (compared to a hard-working honest officer). The overall deterrence might, however, be higher than the one produced by the honest, but shirking, officer. Therefore, the principal might prefer to concentrate on the agent's effort choice. As for the latter, imagine for example a question of issuing driver's licences (or some other license or permit for that matter). In this case, with a relatively well-defined set of criteria, the question of effort (or, the amount of work dealt with) might be less important than the question of non-corrupt decision making in order to avoid the possible social costs that might be generated by, for example, unqualified drivers.

In this paper, I refrain from making specific assumptions about the principal's utility function. Instead, I focus on the decision-making of the agent and on how his incentives are affected by monitoring. This way, the conclusions about the agent's incentives are relatively general, as they do not depend on the specific preferences of the principal or on the parameters of the model such as the proportion of honest types. Specifically, I analyze the case when the principal wants to induce the "most efficient" strategy profile, which includes high effort and non-corruptibility over both periods.

Cremer (1995) is the article that is most closely related to this study. Cremer used a two-period principal-agent model to demonstrate that increased monitoring (and hence more information about the agent's characteristics) may make it more difficult for the principal to commit to some threats, thereby weakening the agent's

incentives.

Cremer's main result draws on the idea of renegotiation-proofness introduced by Dewatripont (1988). Cremer shows that with efficient monitoring technology (which allows the principal to learn at no cost everything about the agent's type/quality and action choices), the only renegotiation-proof contract will commit the principal to monitoring and to firing the agent who is found to be of low quality. With an inefficient monitoring technology (for which the cost of additional information is infinite and which is therefore analogical to the No Monitoring case), the principal will not conduct monitoring (and will only observe output) and will rehire the agent only if he produced high first-period output.

The intuition behind Cremer's result is that the additional information prevents the principal from committing to some threats. Assume, for example, a situation in which the principal commits to an efficient monitoring technology and, at the same time, she claims to fire the agent if he produces low output. The efficient monitoring technology, however, enables the principal to observe the reasons underlying low output at no cost. If she observes that the agent is of high quality and exerted high effort but was unlucky, the principal would prefer keeping that agent to having to go to the market and hiring a new agent of unknown characteristics (but of lower average quality). Knowing that no threat of such a kind would be credible when the efficient monitoring technology is employed, the agent's incentives are altered.

In Cremer's model the agent's type is his (exogenously given) suitability for the job which the agent cannot control and, thus, he only decides about the effort level. This is the most important difference from this paper, in which I study the possible effects of monitoring when the agent decides about both the effort level and corruptibility.

I find a "Cremer-like" result in the case when the principal monitors the effort choice of the agent. Monitoring of Effort improves the sorting of types. Conse-

quently, the principal cannot credibly threaten to fire the agent every time when observing low output. Therefore, the agent might have more incentive to be corrupt. To induce high effort and non-corruptibility over both periods, the principal has to pay a higher expected wage with Monitoring of Effort than with No Monitoring, to compensate for the lost part of incentives due to reduced risk of getting fired after the first period. Monitoring of Corruption, on the other hand, does not improve the sorting of types. Therefore, the principal's firing rule after the first period is exactly the same as with No Monitoring. Consequently, no "Cremer-like" result emerges. Quite on the contrary, the expected penalty for corruption serves as an additional enforcement mechanism and Monitoring of Corruption negatively affects agent's incentives to be corrupt. As a result, the principal can pay a lower expected wage with Monitoring of Corruption than with No Monitoring (or with Monitoring of Effort) to induce high effort and non-corruptibility over both periods.

Importantly, the results suggest that the effect of monitoring one dimension of the agent's strategy profile may spill over to the other dimension. Specifically, my conclusion differs from that in the motivating literature: the incentives to exert effort are not distorted by monitoring; it is indeed the incentive to be corrupt that might be negatively affected if the principal monitors the agent's effort choice. This is the main contribution of this paper.

The remainder of this paper is structured as follows. In section 2, I discuss the model. First, the main assumptions for the agent and for the principal are presented. Afterwards, I introduce the three types of monitoring technology. In section 3, I provide a discussion of the main result. All proofs can be found in the appendix. Section 4 concludes.

2 The Model

This section summarizes the main assumptions of the proposed model. An overview of the key notation for the model is provided in Table 1.1.

p	-	proportion of honest-type agents in the population
q	-	probability of being lucky
c	-	cost of exerting high effort
δ_c	-	exogenous probability of detecting corruption
δ_e	-	exogenous probability of detecting low effort
F	-	penalty imposed after detecting corruption
B_H/B_L	-	high/low output
A	-	utility from corruption, $A > 0$ for the opportunist
$w_{HH}/w_{HL}/w_{LL}$	-	two-period wage after producing high+high/high+low/low+low output
w_F	-	wage paid to an agent who is fired after the first period
e_H/e_L	-	high/low effort
C/NC	-	corrupt/non-corrupt
$\{e_1CD_1, e_2CD_2\}$	-	agent's strategy; e_iCD_i is effort choice and corruptibility decision (CD) in the period $i, i \in \{1,2\}$, $e_i \in \{e_H, e_L\}$, $CD_i \in \{C, NC\}$
NM	-	No Monitoring
MC	-	Monitoring of Corruption
ME	-	Monitoring of Effort

Table 1: Overview of the key notation.

The main assumptions and the basic structure of the model are summarized in Table 1.2. More details are discussed below.

2.1 The Agent

There are two types of agent. As in Cremer (1995), I assume that p of them are good and $(1-p)$ of them are bad, where $0 < p < 1$. The good type, which I will call honest, is constituted of those agents whose psychic cost of engaging in illegal transactions is high enough to outweigh whatever potential benefits there may be. The bad type, which I will call opportunistic, is constituted of those agents with lower psychic costs, who may be corruptible if the expected benefit of doing so is high enough. An opportunistic agent who decides to take bribes in a given period will be called corrupt; if he decides not to take bribes in a given period, he will be called non-corrupt.[4]

[4]Throughout the text, "honest type"/"honest agent" and "opportunistic type"/"opportunistic agent"/"opportunist" will always refer to an agent's type (his given (non)propensity to corruption). "Corrupt" ("non-corrupt") will refer to the opportunistic agent's decision to (not) take bribes in a given period.

The Agent

is one of two types

· honest type

→ chooses effort level $\in \{e_H, e_L\}$

→ is always non-corrupt

· opportunistic type

→ chooses effort level $\in \{e_H, e_L\}$

→ decides to be corrupt or non-corrupt

the observed productivity of either type depends on

· chosen effort level $\in \{e_H, e_L\}$

· exogenous realization of luck $\in \{lucky, unlucky\}$

· chosen "corruptibility" $\in \{corrupt, non\text{-}corrupt\}$

The Principal

At the beginning of the 1^{st} period offers a two-period contract in which she

· commits to a monitoring technology

→ No Monitoring (NM) – the principal can only observe output realization

→ Monitoring of Corruption (MC) – the principal can observe output and with probability δ_c also detect corruption

→ Monitoring of Effort (ME) – the principal can observe output and with probability δ_e also detect low effort

· specifies two-period wages (w_{HH}, w_{HL}, w_{LL}) and the "firing" wage (w_F)

· specifies conditions under which the agent's employment continues after the first period

At the end of the 1^{st} period

· implements monitoring technology

· decides whether to keep or fire the agent based on the outcome of the monitoring and conditions stated in the contract

→ if she keeps the agent, nothing changes and the two-period contract is fulfilled

→ if she fires the agent, she terminates the two-period contract, pays the agent the "firing" wage w_F, and offers a one-period contract to a new agent.

At the end of the 2^{nd} period

· pays wages according to the applicable contract.

Table 2: Summary of the model.

Both types choose an effort level, which can take one of two possible values: high (e_H), or low (e_L). If the agent exerts high effort, he bears a cost of c, $c > 0$. The cost of exerting low effort is normalized to zero.

Two levels of output are possible – high output (B_H) and low output (B_L). B_H is assumed to be strictly greater than B_L. If exerting low effort, the agent of either type automatically produces low output. Both types of agent are capable of producing high output B_H. The only difference is that an opportunist may, through bribery, extract the difference between high and low output, and thus, at the end of the day the principal will observe low output B_L. If the agent exerts high effort,

then the output he produces further depends on two things: (exogenous) luck and the agent's corruptibility. Denote the probability of being lucky q, $0 < q < 1$. The unlucky agent produces low output. The lucky agent produces high output.

The decision to be corrupt depends on the agent's utility from corruption. I assume that the agent's utility from corruption is A. A represents the agent's utility from extracting for himself through bribes that part of output that is above the output resulting from low effort;[5] it also factors in the agent's psychic cost of corruption. It is not necessary for the purpose of this paper to specify how exactly these factors enter A, though.

For the honest type, I assume that A is equal to zero (their psychic cost of corruption is too high). The opportunists have one specific value of $A > 0$ which is common knowledge.

An opportunistic agent can be corrupt only on lucky days, when he can gain A by extracting the difference between B_H and B_L for himself. If the opportunist is corrupt, the principal will observe low output B_L. Thus, in fact, the realization of an agent's type is in fact equivalent with the realization of A; A is a parametric representation of the type.

I assume that the agent does not know "his" A before starting the job. However, I assume that he learns it right after he starts working and thus is able to adjust the effort level instantly.

2.2 The Principal

A risk-neutral principal offers a two-period contract to an agent of unknown characteristics. Before signing the contract neither the principal nor the agent know

[5]With the minimum output being B_L, the agent can, essentially, extract part of the difference between B_H and B_L. One could specify A as $A = \alpha(B_H - B_L)$, where $\alpha < 1$ – the agent extracts a linear part of the "extra output" and $\alpha < 1$ accounts for the psychic cost of corruption as well as some cost of bargaining (a bribe is typically lower than an actual penalty would be). For the sake of generality I, however, refrain from specifying such a specific relationship between gain from corruption and output. It is not necessary for the purpose of this paper.

the agent's A; only the probability p of the distribution of A in the population is known.

In the two-period contract, the principal specifies the monitoring technology, wages to be paid after the second period, conditions under which the contract continues after the first period and the wage to be paid to the agent in case he is fired after the first period.

After observing the outcome of the first period (how much information is being observed depends on the chosen monitoring technology), the principal decides whether to continue the contract or to fire the agent and to offer a one-period contract to an agent of unknown characteristics. Note that the monitoring, if the principal commits to it, occurs only after the first period, i.e. the principal does not monitor after the second period.[6]

The two-period wages are contingent on observed output and also depend on the rehiring decision of the principal. Wages are paid at the end of the employment. The principal will pay w_{HH} after observing high output in both periods; w_{HL} after observing a combination of high and low output over two periods;[7] w_{LL} after observing low output in both periods;[8] and, finally, she will pay w_F in the case when she fires the agent based on the outcome of the first period (including monitoring in relevant cases).

[6]In this, I follow Cremer's approach. The monitoring, by giving (or not) additional information to the principal after the first period, should in general affect the sorting of the agents after the first period and thereby affect the incentives of the agent. The purpose of this paper is to explore in which direction the incentives are affected. The second period is important ex-ante, so that the agent needs to optimize over two periods and monitoring in between, when deciding about his actions. Basically, the second period captures the lost opportunity of the agent who misbehaves and might be fired afterwards.

[7]Here I implicitly assume symmetry, $w_{HL} = w_{LH}$, as in both cases a total output of $B_H + B_L$ is produced. Note that with some monitoring technologies the agent will be fired after producing B_L in the first period, in which case he will be paid w_F. The details will be discussed later on, as the firing rule is specific to the monitoring technologies chosen and it is part of the results to be shown.

[8]Here, the same comment applies as for w_{HL} - as with some monitoring technologies, the agent will be fired after delivering low output, w_{LL} will not always be relevant. More details follow later on.

2.3 Monitoring Technologies

Based on the agent's strategy space and on the preferences of the principal, three monitoring technologies seem relevant. First, the benchmark case, which I will call *No Monitoring* (NM), in which the principal does not monitor the agent. Second, the case in which the principal can monitor the corruptibility of the agent and discover it with some positive probability. I will call this case *Monitoring of Corruption* (MC). Finally, the case in which the principal can monitor the effort the agent puts in and discover shirking with some positive probability. I will call this case *Monitoring of Effort* (ME).

All three monitoring technologies affect the agent's incentives to exert a high level of effort and to be corrupt; how exactly they affect the agent's incentives is my primary focus.

2.3.1 No Monitoring (NM)

In this case the principal can only observe output at the end of the first period.

Table 1.3 summarizes all the possible combinations of the agent's type, his decisions (about effort and corruptibility), nature's moves (luck) and the result observed by the principal (level of output) after the first period. The two-period case is analogous but more complicated, as it involves combinations of the agent's actions and nature's moves over two periods. Moreover, the continuation of the employment into the second period depends on the outcome observed by the principal after the first period.

Note that the principal observes high output only if she employs either an honest type who exerts high effort and is lucky, or an opportunist who exerts high effort, is lucky and is non-corrupt. In all other cases, the principal observes low output. Consequently, she is not able to distinguish which type she is currently employing based on observed output.

type	**effort**	**luck**	**corruptibility**	**observed output**
HONEST	high (e_H)	lucky	non-corrupt (NC)	B_H
		NOT lucky	non-corrupt (NC)	B_L
	low (e_L)	–	non-corrupt (NC)	B_L
OPPORTUNIST	high (e_H)	lucky	non-corrupt (NC)	B_H
			corrupt (C)	B_L
		NOT lucky	non-corrupt (NC)	B_L
	low (e_L)	–	non-corrupt (NC)	B_L

Table 3: Possible combinations of type, effort, luck, corruptibility and observed output; e_H/e_L stand for high/low effort, NC/C for non-corrupt/corrupt and B_H/B_L for high/low output.

2.3.2 Monitoring of Corruption (MC)

In this case, the principal has access to a technology that allows her to detect corruption with some nonzero probability. I assume that this technology returns no false positive – it does not detect the agent as corrupt if he has not been corrupt. The agent who has been corrupt is detected with probability δ_c, where $0 < \delta_c < 1$, and detection leads to punishment with certainty. Thus, after being detected, the agent is fired. In addition, he is punished by an external law-enforcing authority and a fine F is imposed on him. The fine F and the detection rate δ_c are exogenous parameters.[9]

The principal monitors the agent after observing low output in the first period.

2.3.3 Monitoring of Effort (ME)

In this case, the principal has a technology that allows her to detect low effort. As in the previous case, I assume that the technology returns no false positive – it does not detect the agent as exerting low effort if he has not exerted low effort. The agent who has exerted low effort is detected with probability δ_e, where $0 < \delta_e < 1$. After being detected, the agent is fired with certainty. The detection rate δ_e is an

[9]Typically, the penalties are set by law and collected by an external authority. It is, however, not crucial for this paper who in fact collects the fine, as it is not my goal to identify the optimal contract for the principal; rather I look at incentives of the agent and how they are affected by various monitoring technologies. In the case when the principal would collect the fine, F could be, in fact, simply a part of the wage. As regards the detection rate, one can think of it as the quality (or effectiveness) of the feasible monitoring technology.

exogenous parameter.[10]

The principal monitors the agent after observing low output in the first period.

3 Results

Before discussing the details, Table 1.4 below provides a brief overview of the main results. Specifically, I am looking for the effect that Monitoring of Corruption and Monitoring of Effort (as opposed to No Monitoring) have on: 1) sorting of types ("Does the information from MC/ME help the principal to fine-tune her firing rule?"); and 2) incentives of the agent to be non-corrupt and to exert effort.

	Sorting	**Non-Corruptibility**	**Effort**
MC	$-$	$\uparrow$	$-$
ME	$\uparrow$	$\downarrow$	$-$

Table 4: Effects of Monitoring of Corruption (MC) and Monitoring of Effort (ME) on the sorting of types, agents' corruptibility and effort choice. "$\uparrow$" corresponds to a positive effect, "$\downarrow$" corresponds to a negative effect, and "$-$" corresponds to no effect.

Assumption 1. Throughout the analysis, I assume that the principal prefers the honest type to exert high effort.

In the simplest case, when the principal would set wages such that the honest type would prefer exerting low effort over both periods (the principal might want to do that to reduce her cost), the opportunist would prefer either low effort (when $qA < c$) or high effort and being corrupt (when $qA > c$). In either case, in the end both types would deliver low output. Consequently, firing and replacing the agent with a new one could not help to improve efficiency. Basically, I assume that the levels of output are such that the improvement in efficiency of the honest type outweighs the cost in wages to the principal. This assumption allows concentrating on (strategically) interesting cases and helps to simplify the analysis.

[10]One can think of δ_e as the quality (or effectiveness) of the feasible monitoring technology. With ME, I do not assume an additional external punishment in the form of a penalty, as exerting low effort is not an illegal action.

The principal's Bayesian updating, after observing the first-period output and the result of the monitoring, gives the first result:

Proposition 1. *Monitoring of Corruption does not improve the sorting of types. Monitoring of Effort improves the sorting of types if the probability of detection is high enough.*

Improved sorting means that, based on the result of monitoring, the principal can fine-tune her firing rule (compared to NM) so as to improve her probability of having an honest type for the second period.

The detailed proof can be found in the appendix,; a discussion follows below.

With all three monitoring technologies, there are, in general, three possible first-period strategy profiles for the opportunist: $\{e_H C\}$, $\{e_H NC\}$, $\{e_L NC\}$. According to *Assumption 1*, the principal always prefers the honest type to exert high effort e_H. Altogether, there are three possible strategy profiles that the principal might wish to induce in the first period: $e_H, \{e_H NC\}$, $e_H, \{e_H C\}$, and $e_H\{e_L NC\}$, where the first term denotes the strategy of the honest agent and the second term, in the braces, the strategy of the opportunist. Depending on the particular contract the principal offers, the outcome of the first period can give her more or less information about the type of the agent she is employing. To prove *Proposition 1* I compute for each monitoring technology the updated (a-posteriori) probabilities of having an honest type for all possible first-period strategy profiles and the observed outcomes of the first period. Then I compare the a-posteriori probability of having an honest type with the proportion of honest types on the market.

With No Monitoring, the only information the principal has after the first period is the realization of output. In the first case, when $e_H, \{e_H NC\}$ is induced in the first period, if high output is observed, it could have been produced by either an honest or an opportunistic lucky agent. Similarly, if low output is observed, it could have been produced by either an honest or an opportunistic unlucky agent. After

the first period, the principal has no additional information about the type of the agent compared to the start of the employment and thus her best prediction about the probability that she is indeed employing an honest agent is p. The probability that she would hire an honest agent if she fires her current employee and goes to the market again is the same. Therefore she is indifferent between keeping and firing the currently employed agent.

In the other two cases, when $e_H, \{e_H C\}$ or $e_H, \{e_L NC\}$ is induced in the first period, if high output is observed, the principal knows with certainty that she is employing an honest agent, and she prefers to keep this agent to firing him and employing a new agent of unknown characteristics. If low output is observed, than the a-posteriori probability of having an honest type is lower than the proportion of honest types on the market and therefore, the principal would be better off firing her current employee and hiring a new agent.

Thus, in this case the principal will ex-ante commit to the following firing rule: "I will keep the agent who has produced high output and will fire the agent after observing low output." Ex-post, the principal cannot be better off by not keeping her ex-ante firing rule.

With Monitoring of Corruption, the principal can in addition detect a corrupt agent with some probability. After observing low output, detection is a sufficient signal that the current employee is indeed opportunistic. Unfortunately, no detection is not a sufficient signal of having an honest type (the a-posteriori probability of having honest type is lower than the proportion of honest types on the market). So, in the end, the principal will fire the agent after observing low output, no matter what the result of monitoring is. She will keep the agent who has produced high output. Thus, the principal's firing rule will be the same as in the NM case.[11]

[11] Even though the information generated by the monitoring in this case is not sufficient to improve the sorting of the types (and thus the informational value of the test might seem negligible), it will be shown later that Monitoring of Corruption does affect the incentives of the agent in the desired way and therefore the principal might want to commit to conducting it.

With Monitoring of Effort, the principal can detect a shirking agent with some probability. After observing low output, detection is a sufficient signal that the current employee is indeed opportunistic. Unlike with MC, no detection is a sufficient signal of having an honest type (a-posteriori probability of having an honest type is higher than the proportion of the honest type on the market) if the detection probability $\delta_e > q$. When $e_H, \{e_H C\}$ is induced, ME always returns "no detection" as the opportunist is exerting high effort and thus ME cannot help to obtain additional information. Therefore, in this case, the principal will always fire after observing low output. Altogether, with ME, the principal's firing rule will be based directly on the outcome of the monitoring.[12]

This result might seem surprising at first, but it is in fact a consequence of the structure of the model. Recall that only those opportunists who exert high effort and are lucky can collect bribes (as a part of the "above-the-minimum" output) which, as I argued at the beginning, is indeed a realistic assumption. Thus, corruptibility is conditional on good luck. Consequently, with MC, some opportunists are not detected because the detection technology has failed, others are not detected because "luck did not bring them enough opportunities" to be corrupt. With ME, every opportunist who chooses to exert low effort can be detected. Thus, with MC a smaller proportion of opportunists is detected and therefore, no detection is not a sufficient signal for the principal to keep the agent.

Assumption 2. From now on, I will assume that the principal has access to a Monitoring of Effort technology that is successful enough or, that $\delta_e > q$.

Table 1.5 summarizes the firing rules for all three monitoring technologies. The principal will ex ante commit to these firing rules in the contract. Ex post, the

[12]This improvement in sorting is a possible value added to the principal. The principal, for whom non-corruptibility of her agents is the top priority, might want to bear the extra cost (it will be shown later that the principal has to pay higher expected wages with ME) connected to ME in order to sort out the opportunists. As I said, it is not the purpose of this paper to specify the optimal contract of the principal but rather to explore the possible effects of monitoring on agents' incentives.

principal cannot be better off not keeping her ex-ante rule.

	$e_H, \{e_H NC\}$		$e_H, \{e_H C\}$			$e_H, \{e_L NC\}$		
	B_H	B_L	B_H	$B_L + ND$	$B_L + D$	B_H	$B_L + ND$	$B_L + D$
MN	keep	fire	keep	fire		keep	fire	
MC	keep	fire	keep	fire	fire	keep	fire	
ME	keep	keep	keep	fire		keep	keep	fire

Table 5: Summary of the firing rules with all three monitoring technologies: NM, MC, and ME; e_H/e_L stand for high/low effort, NC/C for non-corrupt/corrupt, B_H/B_L for high/low output, and D/ND for "detection"/"no detection."

Assumption 3. From now on, I will assume that the expected gain from corruption is greater than the cost of exerting high effort, thus $qA > c$.

The further results of the model depend on how the expected gain from corruption compares to the cost of exerting high effort. Depending on that, the opportunist might prefer high effort and corruptibility to exerting low effort or vice versa, which has important consequences for the implementability of various strategy profiles. Therefore, I will distinguish two cases, when $qA \leq c$ and when $qA > c$.

The first case is less interesting because in the benchmark case, with No Monitoring, corruption does not exist. Recall that both $\{e_H C\}$ and $\{e_L NC\}$ lead to low observed output and thereby to firing with certainty. As the expected (net) gain of corruption $qA - c$ is negative, the opportunist will be better off exerting low effort than exerting high effort and collecting bribes. Therefore, corruption is not an issue even without monitoring and the principal-agent interaction becomes, in this case, just a simple problem of effort choice.

The second case is more interesting: corruption is not suppressed by the choice of parameters and can occur with all three monitoring technologies. In fact, as the expected (net) gain of corruption $qA - c$ is positive, the opportunist (unless he is provided extra incentives), prefers $e_H C$ to $e_L NC$ in a single period. Given the interdependence of effort choice and corruptibility, this is an interesting case when the interplay of the incentives to extract bribes and to exert effort becomes an issue. As the purpose of this paper is to examine various effects of monitoring

technologies on agent's corruptibility and effort level, I will concentrate on this case.

Proposition 2 summarizes the main result for Monitoring of Corruption assuming that the principal (exogenously) commits to monitoring and to the optimal firing rule as specified above.

Proposition 2. *The wages sufficient to ensure both high effort and non-corruptibility over both periods are lower with Monitoring of Corruption than with No Monitoring.*

The proof can be found in the appendix. Intuitively, the principal has two main channels of influencing the agent's incentives: the threat of firing after the first period and an incentive-compatible payment scheme (including expected penalty). As to the first, MC does not improve the sorting of types and the firing rule of the principal does not change compared to NM: the principal keeps the agent only after observing high output; low observed output leads to firing with certainty. With an unchanged firing rule, the risk of getting fired is exactly the same as with NM. Consequently, there is no "Cremer-like" (negative) effect on the incentives of the agent that would result from the reduced risk of getting fired.[13] As to the second, in the case of detection, the agent is fired and penalized. Therefore, the threat of penalty serves as an additional enforcement mechanism compared to the NM case. Consequently a lower wage compensation is sufficient from the principal to induce non-corruptibility.

To put it differently, with MC, "No Corruption" is the binding constraint. With $qA > c$, with the threat of getting fired after delivering low output, and with binary effort choice, the principal offers a wage premium to induce non-corruptibility as opposed to corruptibility (and not to induce high effort as opposed to low effort). Once the principal bans corruption (imagine $\delta = 1$), she no longer needs to "bribe"

[13]Recall that according to Cremer (1995) additional information prevents the principal from committing to some threats and therefore might be detrimental to the agent's incentives.

the agent not to take bribes and therefore she can lower the wage a little bit and still ensure his non-corruptibility. Thus, MC allows maintaining high effort and non-corruptibility with a lower wage.

The presence of the expected penalty allows the principal to change the wage structure, which results in lower expected wage for the agent but the threat of firing after the first period maintains the incentives to exert effort.[14]

Monitoring of Effort is more interesting, as in this case, the principal's firing rule is based on the result of monitoring (and it is different than with NM), which is why a "Cremer-like" (negative) effect on agent's incentives can be expected. *Proposition 3* summarizes the main result for ME, assuming that the principal (exogenously) commits to monitoring and to the optimal firing rule as specified above.

Proposition 3. *The wages necessary to ensure both high effort and non-corruptibility over both periods are higher with Monitoring of Effort than with No Monitoring.*

A detailed proof can be found in the appendix. When the principal wants to induce high effort and non-corruptibility over two periods from both types of agent, with No Monitoring the wages $w_{HH} = 2A - (qA - c)$, $w_{HL} = A - (qA - c)$, and $w_F = 0$ are sufficient; with Monitoring of Effort, she has to offer $w_{HH} = 2A$, $w_{HL} = A$, $w_{LL} = 0$, and $w_F = 0$ to induce the same strategy profile. It follows immediately from *Assumption 1* that the No-Monitoring wages are lower.

This result has the flavor of Cremer's (1995) main result: additional information to the principal about the agent makes some threats not credible and thereby weakens the incentives of the agent. Consequently, in order to induce the same strategy profile, the principal has to compensate with higher wages. The optimal

[14] A simple exercise can be done to illustrate how MC affects the incentives of the agent. Assume that the principal would commit to the NM technology but with (lower) MC-incentive-compatible wages. All the other conditions of the contract would remain unchanged. It is easy to show that in such a case the opportunist would switch to $\{e_H C\}$ in the first period (and get fired afterwards). Importantly, the absence of monitoring and of the expected penalty results in increased corruption. Given that $qA > c$ and that both $\{e_H C\}$ and $\{e_L NC\}$ lead to firing with certainty, the agent prefers $\{e_H C\}$ to $\{e_L NC\}$ in the first period. Either higher wages or the threat of penalty are necessary to ensure the non-corruptibility of the agent.

firing rule for ME is different than for NM, as "no detection" is a sufficient signal for the principal to keep the agent even after delivering low output. Consequently, as in Cremer (1995), the principal cannot credibly threaten to fire every agent who has delivered low output, which weakens the incentives of the agent.

ME affects the incentives of the honest type to exert high effort and the incentives of the opportunistic type to be non-corrupt. The binding constraint is, again, the one ensuring non-corruptibility of the opportunistic type. Let me illustrate why.

First, assume the extreme case when the monitoring technology is perfect, and thus $\delta = 1$. The honest type will continue exerting high effort, because otherwise he would be detected and fired with certainty. The opportunist, however, even when $\delta = 1$, has incentives to switch to $\{e_H C\}$ and here is why.[15] With NM, going from $\{e_H NC\}$ to $\{e_H C\}$ would increase his probability of getting fired from $(1 - q)$ to 1 as $\{e_H C\}$ leads to low observed output and firing. With ME, on the other hand, his probability of getting fired would drop to zero, as after observing low output the principal would monitor the agent and the test for low effort would return "no detection." Clearly, the incentives to switch to $\{e_H C\}$ are stronger with ME than with NM, and that is why the principal has to "bribe" the agent not to take bribes.

Second, when the monitoring technology is not perfect, and thus $\delta < 1$, the incentives of the honest type will be affected. In this case, the honest type's probability of getting fired after exerting low effort would be 1 with NM (because he delivers low output he is fired), whereas it is only $\delta < 1$ with ME. Therefore, as in Cremer (1995), the principal has to compensate what is lost on incentives due to the "lower threat of firing" by offering a higher wage to the agent.

The fact that the binding constraint is that on non-corruptibility follows from

[15] Assume that the principal offers wages to induce high effort and non-corruptibility over both periods. I want to compare the incentives of the opportunist to switch $\{e_H C\}$ in the first period under NM vs. ME. Also, keep in mind *Assumption 3* that $qA > C$, which ensures that the opportunist always prefers high effort and corruption to exerting low effort.

the assumption that $qA > c$ (*Assumption 3*) and thus the opportunist always prefers $\{e_H C\}$ to $\{e_L NC\}$.[16] Consequently, when the constraint on non-corruptibility is binding, the incentive-compatibility constraint of the honest type to exert effort is satisfied automatically. If we were to reduce the wages, such that the effort constraint would be binding, the opportunistic type would switch to corruption (see *Proposition 4* below). Importantly, the higher wages that the principal has to offer with ME to ensure that the opportunistic type is non-corrupt are high enough to also ensure that the honest type exerts high effort.

To support the above arguments and to illustrate how exactly the incentives of the two types are affected by ME, I also did a simple exercise looking at a hybrid monitoring technology which combines some properties of No Monitoring and of Monitoring of Effort. The results are summarized in *Proposition 4*.

Proposition 4. *ME can negatively affect the opportunist's incentives to be non-corrupt.*

a) When the principal maintains the same $\{e_H NC, e_H NC\}$ wages as with NM while introducing ME, the opportunist's strategy profile will involve corruption. The incentives of the honest type are not distorted.

b) When the principal implements ME but cannot offer higher expected wages than with NM,[17] the best strategy profile $\{e_H NC, e_H NC\}$ is no longer implementable.

The detailed proof can be found in the appendix. When the principal offers the NM wages, $w_{HH} = 2A - (qA - c)$, $w_{HL} = A - (qA - c)$, and $w_F = 0$, to induce $\{e_H NC, e_H NC\}$ but introduces ME,[18] the opportunist no longer prefers

[16] This assumption ensures that the expected gain from corruption is sufficient to compensate for the cost of high effort and therefore corruption is indeed a problem.

[17] Thus, the contract that the principal offers has all the properties of ME but her budget constraint does not allow her to pay more (in expectations) than she would with NM.

[18] Thus, the contract that the principal offers has all the properties of ME, just the wages that she offers are the NM-incentive-compatible wages.

$\{e_H NC, e_H NC\}$. Instead, he will prefer $\{e_H NC, e_H C\}$. Thus, when the principal introduces ME with (lower) NM wages, the second-period incentives are distorted and, specifically, they invoke corruption. Intuitively, the second period incentives are the first to be affected by lower wages, as there is no monitoring after the second period. Given that $qA > c$ the opportunist always prefers $\{e_H C\}$ to $\{e_L NC\}$ in a one-period horizon. As lower wages are weakening the incentives of the opportunist, he will naturally switch to $e_H C$ rather than to $\{e_L NC\}$ to be able to extract extra $qA - c > 0$. The incentives of the honest type to exert effort are not distorted, which is, as I discussed above, a consequence of $qA > c$, an assumption which ensures that when reducing the wages, it is first the constraint on non-corruptibility that breaks down, while the effort constraint is still satisfied.

The proof of part *b)* can be also found in the appendix. When the principal implements Monitoring of Effort but does not want to spend, in expectation, more than with No Monitoring, the best strategy profile $\{e_H NC, e_H NC\}$ is no longer implementable. Therefore, the principal, depending on her preferences, would have to offer a contract that would induce an alternative strategy profile.

4 Conclusion

In the two-period principal-agent model in which an agent of unknown propensity to corruption decides about his effort level and corruptibility (both his action choices hidden to the principal), I show that imperfect partial Monitoring of Effort with a high enough detection rate improves the sorting of types. It might, however, also support agent's incentive to be corrupt. In contrast, Monitoring of Corruption does not improve the sorting of types and it negatively affects the incentive of the agent to be corrupt.

In particular, I show that when the expected gain from corruption is high enough and corruption might exist with No Monitoring, it is more expensive for the prin-

cipal to induce a high level of effort and non-corruptibility over two periods with Monitoring of Effort than with No Monitoring. Monitoring of Effort positively affects the incentive of the agent to be corrupt. This result is in line with earlier findings in the career concerns literature (Cremer 1995; Holmström 1999; Dewatripont, Jewitt, and Tirole 1999; Prat 2005) that additional information to the principal about her agent prevents the principal to credibly commit to some threats and thereby might weaken the incentives of the agent to exert high effort in order to signal high ability. In contrast, Monitoring of Corruption, even though it does not improve the sorting of types – or, in fact, thanks to it – does not have this detrimental effect on the agent's incentives. With Monitoring of Corruption, the principal does not rely on the result of monitoring (specifically, "no detection" is not a sufficient signal to keep the agent for the second period) and therefore, the firing rule is the same as with No Monitoring. Consequently, there is no "Cremer-like" negative impact on the agent's incentives. As the expected penalty serves as an additional enforcement mechanism, lower expected wages are necessary to induce high effort and non-corruptibility over two periods than with No Monitoring (and than with Monitoring of Effort).

A policy implication can be drawn from the results. When the agent's propensity to corruption is hidden to the principal, and when the agent's actions are not directly observable and might also depend on exogenous random realization (luck), the principal might want to rely on an (stricter) output-contingent firing rule and monitor for corruption even though this monitoring technology does not improve the sorting of types. Monitoring of Effort is inferior to both Monitoring of Corruption and No Monitoring, in that it distorts the incentives to be non-corrupt. This conclusion is drawn for the principal who wants to induce the most efficient strategy profile that involves high effort and non-corruptibility over both periods.

A conclusion can be drawn also for the case of Czech traffic police officers that

motivated this investigation. The cameras installed in the police cars, even if one would doubt their effectiveness as a mean of detecting corruption and providing admissible evidence, could help to improve the officers' incentives when implemented together with a properly designed reward and punishment system.

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APPENDIX

Proof of Proposition 1. With all three monitoring technologies, there are three possible first-period strategy profiles for the opportunist: $e_H C$, $e_H NC$, $e_L NC$. According to *Assumption 1*, the principal always prefers the honest type to exert high effort. The principal can offer various contracts (various wages to induce various two-period strategy profiles of the opportunist), each of which would involve one of the above-mentioned first-period strategies.

For each monitoring technology, I compute the probability of having an honest type given the induced first-period strategy profile and observed outcome of the first period (including monitoring, if relevant). Recall the Bayesian updating rule:

$$P(honest/outcome) = \frac{P[honest] \cdot P[outcome/honest]}{P[outcome]}$$ [19]

NM: With NM, the only new information the principal has after the first period is the output realization.

1) If $e_H, \{e_H NC\}$ is induced, then $P[honest/B_L] = \frac{(1-q)p}{(1-q)} = p$ and $P[honest/B_H] = \frac{qp}{q} = p$. Thus the a-posteriori probability of having an honest type is the same as the a-priori probability (and as the probability of the honest type on the market) after both B_H and B_L. Therefore in this case, the principal is indifferent between keeping and firing her current employee. $P[honest/B_H] = \frac{qp}{q} = p$

2) If $e_H, \{e_H C\}$ is induced, then $P[honest/B_L] = \frac{(1-q)p}{(1-pq)} < p$. Thus the the a-posteriori probability of having an honest type is lower than the a-priori probability. More importantly, it is lower than the probability of obtaining an honest type on the market. Therefore in this case, the principal would be better off firing her current employee and hiring a new one for the second period after observing B_L.

[19] Note that Table 1.3 provides a review of all the possible combinations of the agent's type, decisions, luck, and observed output after the first period, which can be useful for the computations of these probabilities.

As $P[honest/B_H] = 1$, the principal wants to keep her current employee after observing B_H.

3) If $e_H, \{e_L NC\}$ is induced, then $P[honest/B_L] = \frac{(1-q)p}{(1-pq)} < p$. Thus the the a-posteriori probability of having an honest type is lower than the a-priori probability (and than the probability of obtaining an honest type on the market). Therefore in this case, the principal would be better off firing her current employee and hiring a new one for the second period after observing B_L. As $P[honest/B_H] = 1$, the principal wants to keep her current employee after observing B_H.

All in all, the principal will fire her current employee after observing low output and keep the agent otherwise.

MC: With MC, the principal observes output and the result of Monitoring of Corruption after the first period. Therefore, the "outcome" has now two components: "observed output" and "detection (D) or no detection (ND)." Note that the honest type is never corrupt and therefore never detected and thus $P[honest/B_L + D] = 0$ always (and $P[opportunistic/B_L + D] = 1$ so detection will always lead to firing). Also, the principal does not monitor after observing B_H as a "misbehaving" agent never produces high output.

1) If $e_H, \{e_H NC\}$ is induced, then $P[honest/B_L + ND] = \frac{(1-q)p}{(1-q)} = p$, and $P[honest/B_H] = p$. Thus in this case, the principal is indifferent between keeping and firing her current employee.

2) If $e_H, \{e_H C\}$ is induced, then $P[honest/B_L + ND] = \frac{(1-q)p}{(1-pq-q\delta_c+pq\delta_c)} < p$, and $P[honest/B_H] = 1$. Thus in this case, the principal would be better off firing her current employee after observing low output (with detection as well as without) and hiring a new one for the second period. She will only keep her current employee after observing high output.

3) If $e_H, \{e_L NC\}$ is induced, then $P[honest/B_L + ND] = \frac{(1-q)p}{(1-pq)} < p$, and $P[honest/B_H] = 1$. Thus in this case, the principal would be better off firing her

current employee after observing low output (with detection as well as without) and hiring a new one for the second period. She will only keep her current employee after observing high output.

All in all, the principal's firing rule will be the same as in the NM case. Even though the updated probabilities of having an honest type after the first period are not the same as with NM, the principal does not acquire sufficient information to base the firing upon the result of the monitoring. Or, to say it differently, no detection is not a sufficient signal of having an honest type. Therefore, similarly as with NM, the principal will fire her current employee after observing low output and keep the agent otherwise.

ME: With ME, the principal observes output and the result of Monitoring of Effort after the first period. Therefore, the "outcome" now has two components: "observed output" and "detection (D) or no detection (ND)." Note that the principal always prefers the honest type to exert high effort and therefore $P[honest/B_L{+}D] = 0$ always (and $P[opportunistic/B_L + D] = 1$ so detection will always lead to firing). Also, the principal does not monitor after observing B_H as a "misbehaving" agent never produces high output.

1) If $e_H, \{e_H NC\}$ is induced, then $P[honest/B_L + ND] = \frac{(1-q)p}{(1-q)} = p$, and $P[honest/B_H] = p$. Thus in this case, the principal is indifferent between keeping and firing her current employee.

2) If $e_H, \{e_H C\}$ is induced, then $P[honest/B_L + ND] = \frac{(1-q)p}{(1-pq)} < p$, and $P[honest/B_H] = 1$. Thus in this case, the principal would be better off firing her current employee after observing low output (with detection as well as without) and hiring a new one for the second period. She will only keep her current employee after observing high output.

3) If $e_H, \{e_L NC\}$ is induced, then $P[honest/B_L + ND] = \frac{(1-q)p}{(1-\delta_e+p\delta_e-pq)} > p$ if $\delta_e > q$, and $P[honest/B_H] = 1$. Thus in this case, the principal would be better off

keeping her current employee after observing low output and no detection as well as after observing high output. She will only fire after detection.

All in all, with ME, the principal can base her firing rule on the outcome of the monitoring. When e_HC is induced then low output is a sufficient signal for firing the agent. When e_LNC is induced, then no detection is a sufficient signal of having an honest type if $\delta_e > q$. Therefore, the principal will fire her current employee in two cases: if a) e_HC is induced and B_L is observed, or b) e_LNC is induced and $B_L + D$ is observed. Thus, ME improves the sorting of types.

□

Proof of Proposition 2. For both NM and MC I will set up the principal's problems. The principal minimizes the expected wage such that the strategy profile $\{e_HNC, e_HNC\}$ from both types is incentive-compatible.

NM: Recall that with NM after delivering low output in the first period the agent is fired with certainty. The principal maximizes

$$-q[qw_{HH} + (1-q)w_{HL}] - (1-q)w_F.$$

The second-period incentives of the honest type are ensured by

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL}.$$

The first-period incentives of the honest type are ensured by

$$q[qw_{HH} + (1-q)w_{HL} - c] + (1-q)w_F - c \geq w_F.$$

The opportunist must, in addition, prefer being non-corrupt to being corrupt. The opportunist's second-period incentives are therefore ensured by

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL},$$

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL} + qA - c.$$

The first period incentives of the opportunist are ensured by

$$q[qw_{HH} + (1-q)w_{HL} - c] + (1-q)w_F - c \geq w_F,$$

$$q[qw_{HH} + (1-q)w_{HL} - c] + (1-q)w_F - c \geq w_F + qA - c.$$

The agent's (ex-ante) participation constraint is

$$q[qw_{HH} + (1-q)w_{HL} - c] + (1-q)w_F - c \geq 0.$$

The participation constraint does not depend on probability p as both types are induced the same strategy profile. It is easy to show that given the incentive-compatibility and non-negativity constraints on wages, the agents' participation constraint holds as well.

The optimal wages satisfying the incentive-compatibility constraints are

$$w_{HH} = (2-q)A + c, w_{HL} = (1-q)A + c, w_F = 0.$$

MC: Recall that with MC the firing rule is the same as with NM. The principal maximizes

$$-q[qw_{HH} + (1-q)w_{HL}] - (1-q)w_F.$$

The incentives of the honest agent are ensured by

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL},$$

$$q^2 w_{HH} + q(1-q)w_{HL} + (1-q)w_F - (1+q)c \geq w_F.$$

The incentives of the opportunist are ensured by

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL},$$

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL} + qA - c,$$

$$q^2 w_{HH} + q(1-q)w_{HL} + (1-q)w_F - (1+q)c \geq w_F,$$

$$q^2 w_{HH} + q(1-q)w_{HL} + (1-q)w_F - (1+q)c \geq w_F + q(A - \delta_c F) - c.$$

The agent's (ex-ante) participation constraint is

$$q[qw_{HH} + (1-q)w_{HL} - c] + (1-q)w_F - c \geq 0.$$

The participation constraint does not depend on probability p as both types are induced the same strategy profile. It is easy to show that given the incentive-compatibility and non-negativity constraints on wages, the agents' participation constraint holds as well.

The optimal wages satisfying the incentive-compatibility constraints are:

i)for $c \geq q(A - \delta_c F)$ and

ia) for $A \leq \frac{(1+q)c}{q^2} : w_{HH} = (1-q)A + \frac{(1+q)c}{q}, w_{HL} = -qA + \frac{(1+q)c}{q}, w_F = 0,$

ib) for $A > \frac{(1+q)c}{q^2} : w_{HH} = A, w_{HL} = w_F = 0.$

ii) for $c < q(A - \delta_c F)$ and

iia) for $A \leq \frac{(1+q)c}{q^2} or A > \frac{(1+q)c}{q^2}$ & $F \leq \frac{(1-q)A+c}{\delta_c}$:

$w_{HH} = (2-q)A + c - \delta_c F, w_{HL} = (1-q)A + c - \delta_c F, w_F = 0$, or

iib) for $A > \frac{(1+q)c}{q^2}$ & $F > \frac{(1-q)A+c}{\delta_c} : w_{HH} = A, w_{HL} = w_F = 0.$

As $qA > c$, it is easy to show that all the MC wages are lower than wages with MN. Also the ex-ante expected wage cost to the principal is lower with MC for all parameters. Thus, it is more expensive for the principal to induce the same strategy profile with NM than with MC.

□

Proof of Proposition 3. Now I need to set up the principal's problem for ME. The principal minimizes the expected wage such that the strategy profile $\{e_H NC, e_H NC\}$ from both types is incentive-compatible.

NM: Recall that with NM, the optimal wages satisfying the incentive-compatibility

constraints are

$$w_{HH} = (2-q)A + c, w_{HL} = (1-q)A + c, w_F = 0.$$

ME: Recall that with ME the principal fires the agent after he exerted low effort and was detected, or after observing B_L when $e_H, \{e_H C\}$ is induced in the first period. The principal maximizes

$$-q[qw_{HH} + (1-q)w_{HL}] - (1-q)[qw_{HL} + (1-q)w_{LL}].$$

The incentives of the honest agent are ensured by

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL},$$

$$qw_{HL} + (1-q)w_{LL} - c \geq w_{LL},$$

$$q^2 w_{HH} + 2q(1-q)w_{HL} + (1-q)^2 w_{LL} - 2c \geq \delta_e w_F + (1-\delta_e)(qw_{HL} + (1-q)w_{LL} - c).$$

The incentives of the opportunist are ensured by

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL},$$

$$qw_{HL} + (1-q)w_{LL} - c \geq w_{LL},$$

$$qw_{HH} + (1-q)w_{HL} - c \geq w_{HL} + qA - c,$$

$$qw_{HL} + (1-q)w_{LL} - c \geq w_{LL} + qA - c,$$

$$q^2 w_{HH} + 2q(1-q)w_{HL} + (1-q)^2 w_{LL} - 2c \geq w_F + qA - c,$$

$$q^2 w_{HH} + 2q(1-q)w_{HL} + (1-q)^2 w_{LL} - 2c \geq \delta_e w_F + (1-\delta_e)(qw_{HL} + (1-q)w_{LL} - c).$$

The agent's (ex-ante) participation constraint is

$$q^2 w_{HH} + 2q(1-q)w_{HL} + (1-q)^2 w_{LL} - 2c \geq 0.$$

The participation constraint does not depend on probability p as both types are induced the same strategy profile. It is easy to show that given the incentive-compatibility and non-negativity constraints on wages, the agents' participation

constraint holds as well.

The optimal wages satisfying the incentive-compatibility constraints are

$$w_{HH} = 2A, w_{HL} = A, w_{LL} = 0, w_F = 0.$$

As $qA > c$, it is easy to show that wages with NM are lower than wages with ME. Also, the ex-ante expected wage cost to the principal is lower with NM. Thus, it is more expensive for the principal to induce the same strategy profile with ME than with NM. □

Proof of Proposition 4. **a)** First, I will show that if the principal offers NM wages but introduces Monitoring of Effort the opportunist's incentives to be non-corrupt are weakened.

Assume that the principal offers NM wages $w_{HH} = (2-q)A + c, w_{HL} = (1-q)A + c$, and $w_{LL} = w_F = 0$.

a) If the principal introduces ME, the opportunist's expected payoffs from all possible strategy profiles will be as in Table 1.6.

strategy profile	expected 2-period payoff	expected 2-period payoff with NM wages
$\{e_H NC, e_H NC\}$	$q^2 w_{HH} + 2q(1-q)w_{HL} + (1-q)^2 w_{LL} - 2c$	$(q^2 - 2q + 2)(qA - c)$
$\{e_H NC, e_H C\}$	$qw_{HL} + (1-q)w_{LL} + qA - 2c$	$(2-q)(qA - c)$
$\{e_H NC, e_L NC\}$	$qw_{HL} + (1-q)w_{LL} - c$	$(1-q)(qA - c)$
$\{e_L NC, e_H NC\}$	$\delta_e w_F + (1-\delta_e)(qw_{HL} + (1-q)w_{LL} - c)$	$(1-\delta_e)(1-q)(qA - c)$
$\{e_L NC, e_H C\}$	$\delta_e w_F + (1-\delta_e)(w_{LL} + qA - c)$	$(1-\delta_e)(qA - c)$
$\{e_L NC, e_L NC\}$	$\delta_e w_F + (1-\delta_e)w_{LL}$	0
$\{e_H C, --\}$	$w_F + qA - c$	$qA - c$

Table 6: The opportunist's expected wages for all possible strategy profiles when ME is introduced with NM wages.

It is easy to show that (as $0 < q < 1, 0 < \delta_e < 1, c > 0, A > 0$, and $qA > c$) the opportunist will ex-ante prefer the strategy profile $\{e_H NC, e_H C\}$. The strategy space of the honest type is a subset of the strategy space of the opportunist. For the honest type only those strategy profiles that do not involve corruption are relevant. It is easy to check that the incentives of the honest type are not affected - he will still prefer the strategy profile $\{e_H NC, e_H NC\}$.

Now, we also need to check the ex-post incentives of the agent who is standing at the beginning of the second period. Table 1.7 summarizes the expected (two-period) payoffs contingent on the first-period outcome and on the results of monitoring.[20]

1^{st}-period strategy & outcome	2nd-period strategy	expected 2-period payoff	expected 2-period payoff with NM wages
e_H NOT lucky $\Rightarrow B_L$ (or e_L)	$e_H NC$	$qw_{HL} + (1-q)w_{LL} - c$	$(1-q)(qA-c)$
	$e_H C$	$w_{LL} + (qA - c)$	$(qA - c)$
	e_L	w_{LL}	0
e_H lucky $\Rightarrow B_H$ non-corrupt	$e_H NC$	$qw_{HH} + (1-q)w_{HL} - c$	A
	$e_H C$	$w_{HL} + (qA - c)$	A
	e_L	w_{HL}	$A - (qA - c)$

Table 7: The opportunist's expected wages for all possible strategy profiles when MC is introduced with NM wages.

It is easy to show that the opportunist cannot be better of by not keeping to his ex-ante chosen strategy profile. For the honest type, his strategy space consists of the strategies that do not involve corruption. It is easy to show that the second-period incentives of the honest type are not affected. Thus, with ME the opportunist now prefers the strategy profile $\{e_H NC, e_H C\}$.

b) To prove this part of the proposition, we solve the same problem as in the proof of *Proposition 3*, just with additional budget constraints of the principal. With NM, the principal's expected cost is $q^2 w_{HH} + q(1-q)w_{HL} + (1-q)w_F$, which, with optimal wages $w_{HH} = (2-q)A + c, w_{HL} = (1-q)A + c$, and $w_F = 0$, is equal to $q(A + c)$. Thus, the additional budget constraint for ME is $q^2 w_{HH} + 2q(1 - q)w_{HL} + (1-q)^2 w_{LL} \leq q(A + c)$. With ME and the additional budget constraint, the strategy profile $\{e_H NC, e_H NC\}$ is no longer implementable. □

[20] Recall that being corrupt in the first period, the opportunist delivers low output and therefore is fired. Therefore, such a first-period strategy is not relevant for an agent deciding about his second-period strategy.

Individual researchers, as well as the on-line and printed versions of the CERGE-EI Working Papers (including their dissemination) were supported from the following institutional grants:

- Economic Aspects of EU and EMU Entry [Ekonomické aspekty vstupu do Evropské unie a Evropské měnové unie], No. AVOZ70850503, (2005-2010);
- Economic Impact of European Integration on the Czech Republic [Ekonomické dopady evropské integrace na ČR], No. MSM0021620846, (2005-2011);

Specific research support and/or other grants the researchers/publications benefited from are acknowledged at the beginning of the Paper.

Published by
Charles University in Prague, Center for Economic Research and Graduate Education (CERGE)
and
Economics Institute ASCR, v. v. i. (EI)
CERGE-EI, Politických vězňů 7, 111 21 Prague 1, tel.: +420 224 005 153, Czech Republic.
Printed by CERGE-EI, Prague
Subscription: CERGE-EI homepage: http://www.cerge-ei.cz

Editors: Directors of CERGE and EI
Managing editors: Deputy Directors for Research of CERGE and EI

ISSN 1211-3298
ISBN 978-80-7343-207-2 (Univerzita Karlova. Centrum pro ekonomický výzkum
a doktorské studium)
ISBN 978-80-7344-196-8 (Národohospodářský ústav AV ČR, v. v. i.)

CERGE-EI
P.O.BOX 882
Politických vězňů 7
111 21 Praha 1
Czech Republic
http://www.cerge-ei.cz