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Contents

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Kevin Remmy

Executive Summary

This dissertation consists of three essays dealing with the concept of career concerns. Exhibiting the desire to be perceived favorably by others is at the core of this concept. For over three decades researchers have been investigating this concept in theory and in practice. This thesis contributes to the theoretical strand of literature with three models. While each essay highlights a different organizational issue, the common ground of all three is the relationship between a principal (she) and a career concerned agent (he).

Essay 1 studies the effect of career concerns with respect to one of the fundamental organizational questions arising naturally in business: how should a job consisting of two sequential tasks be allocated among the employees? Should the same agent be in charge (integration), or should different agents be in charge (separation)? We find a well-known rent-saving effect favoring integration and a novel shirking effect favoring separation. This shirking effect is purely due to the career concerns of the agent. A project, which is always successful might undermine the contribution of the agent in charge. The agent then has an incentive to shirk in one stage of the project, just to show that the project's success is due to the agent's contribution. In case of separation, the agent has one task only to signal his ability, and hence is well incentivized.

Essay 2 considers an agent who serves as an expert. He investigates the circumstances for an investment. Depending on the underlying state of the

world, a risky or a safe project should be executed. His career concerns, contrary to the ones in Essay 1, target at the correctness of his evaluation. We examine the role of information an outside party has access to as an incentive instrument for a career concerned expert. Two distinguished degrees of information are considered, intransparency and transparency. The latter allows the market to have access to additional relevant information with respect to the agent's evaluation. Making an organization transparent comes at a cost, but nevertheless we find instances where transparency is optimal due to the expert's career concerns. His incentives are increased once the market has superior inference capability, i.e. once the organization is made transparent.

Finally, Essay 3 examines the interplay between explicit and implicit incentives of a career concerned agent. Akin to Essay 2 the agent is modeled as an expert who investigates the nature of a project whose outcome depends on the underlying state of the world. While the modeling of the career concerns is similar to Essay 2, the focus is different. This time the principal has two instruments at hand to incentivize the career concerned agent, namely offering a bonus contingent on a well performed project and secondly, a double-check after a rejected project. The latter generates the information about the correctness of the agent's decision. We find that the principal prefers to offer a bonus if the prior probability of implementing correctly is sufficiently low. The use of double-checks is preferred, otherwise.

Essay 1: Separation vs. Integration subject to Career Concerned Agents

Kevin Remmy [*]

Abstract

We employ a two-staged hidden action model with risk-neutral agents who exhibit not only limited liability but also career concerns. A risk neutral principal then hires either one (integration) or two agents (separation) to work on this two-staged project. The project itself can be easy or difficult. While an easy project always succeeds, exerting effort by an agent can increase the success probabilities of a difficult project. Investigating the optimal organizational form, we find integration to benefit from a well-known rent-saving effect, but to suffer from a novel shirking incentive in the second stage. After a successful first stage, an agent working in both stages might welcome a second stage failure in order to produce a perfect signal of the project being difficult. In case of separation, this effect is not present, as two different agents are working in each stage.

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1.1 Introduction

According to a recent PricewaterhouseCoopers (2011) survey one key indicator of business success is innovation. The survey asked 1200 CEOs around the world. The process of innovation roughly consists of two sequential phases, the R&D phase and the commercialization phase.[1] One important determinant of innovation realization is the organization of these two phases. Should be one economic party be in charge of both phases (integration) or should control over both phases be divided up between two parties (separation)? Particularly, we examine the effect of career concerned parties, where each party's decision is also influenced by the desire to be perceived favorably by the market. Our model uses principal-agent theory to shed light on this organizational question. A principal hires either one agent performing both stages or two agents working on one stage each. From the perspective of an integrated organization, our findings are a well-known rent-saving effect[2] and a novel shirking effect which is purely due to the reputational considerations of the agent. To fix ideas, consider a principal hiring either one (integration) or two (separation) agents to work on a two-staged project which can either be easy or difficult. If the project is of easy type, then it is assumed to always succeed in each stage. If the project is difficult, however, then the success probability of each stage depends on the agent's type who is either smart or dumb. Additionally, the success probabilities depend on the agent's effort which is also modeled binary, thus either the agent exerts effort or not. Effort is costly and unobservable. Assuming only a smart agent's effort improves the success probabilities, a successful first stage signals either the project is easy or the agent is smart. Under integration then, the agent has the incentive to shirk in the second stage after a first-stage success, as a failure in the second stage allows the market to infer that the project is of

[1] Compare figure 1.1. in Greenhalgh et al. (2010).
[2] Compare Laux (2001).

difficult type and as a consequence the first-stage success is likely made by a smart agent. This incentive is the more present the higher the agent values his career concerns. On the other hand a failure in the second stage results in a lower payment, since the principal is interested in a success and hence, agrees on higher payments for success than for failures.
Most closely related to our model is Schmitz (2005), where smart agents are working on difficult projects only. As a consequence, his findings are also present in our model. Schmitz (2005) argues that the principal saves the payment to incentivizes the agent in the first stage under integration as the agent exerts effort anyway in order not to miss the second stage rent. This rent-saving effect of an integrated organization is openly present in our model. Schmitz (2005) finds the downside of integration to be the agent's incentive to shirk in the first stage due to the assumption that the success probabilities in the second stage depend on the first-stage outcome. As a result, the benefit of effort is lowered in the second stage after a first-stage failure and thus the principals offered payment needs to compensate for this circumstance. In anticipation of this, the agent has an incentive to shirk in the first stage. While the entire logic of the drawback is also present in our model, our focus however, is totally distinct namely on the incentive to shirk in second stage which is not present in Schmitz (2005)'s model. Schmitz (2005)'s finding is based on the assumption that the first stage incentive constraint is stronger once the principal prefers to incentivize the agent in the second stage even after a first stage failure. Our model instead assumes the second stage constraint to be binding such that shirking in the first stage is present but not decisive.
Looking at a broader perspective, two strands of literature are brought together, the task assignment literature on the one hand and the career concern literature on the other hand. Initiated by Milgrom and Holmström (1991)'s seminal paper, the focus of the task assignment literature has long been on

multitasking problems arising within a principal - agent setting as trade-offs between insurance and incentives of risk averse agents. Our model however focuses on risk neutral agents bounded by wealth constraints.[3] Moreover, critical to our model is the assumption of tasks being performed sequentially.[4] Laux (2001) analyzes a principal-agent model with multiple projects. He finds a rent-saving effect for a risk neutral principal hiring a risk neutral agent who exhibits limited liability. The agent is willing to exert effort on an additional project in order not to risk the rent of the first project. Consequently, Laux (2001) argues that it is optimal for the principal to offer incentive schemes contingent on multiple projects. Besides Schmitz (2005), several articles have highlighted different aspects corresponding to these assumptions. For instance, Schmitz (2012) considers an outcome externality between tasks. A conflict of tasks results in a reduced success probability of the second stage after a first - stage success. Similarly, a synergy of tasks is given by an increased success probability of the second stage after a first - stage success. Schmitz (2012) finds integration to be superior if tasks are in conflict due to the fact that a hired agent has an additional incentive to exert effort in the first stage, since a first stage success ensures a high bonus for a second stage success due to a reduced effectiveness of effort. Our model considers the case of synergy of tasks because we assumed a first stage success indeed increases the expected success probability of the second stage. Contrary to Schmitz (2012), the principal does not earn any rent in the first stage, but only after a second stage success. As a result, integration might be superior due to a rent-saving effect.

Khalil et al. (2006) investigate a hybrid model considering both moral hazard and adverse selection issues. While exerting unobservable effort to improve

[3]Compare Innes (1990) who was the first to analyze the assumption of limited liability within a moral hazard context.

[4]Compare Bolton and Dewatripont (2005), Chapter 6.2 for simultaneous models with risk neutral agents and hidden actions.

success probabilities in first stage captures the moral hazard component, the outcome of the first stage remains unknown to the principal, but is known by the performing agent. This leads to an adverse selection problem for the second stage. Che and Hoo (2001) on the other hand focus purely on moral hazard problems, like we do. Their focus, however, is on investigating the optimality of hiring a team of two identical agents to perform in each stage instead of one. Jost and Lammers (2010) introduce an initial screening phase before the implementation phase of the project. Akin to Sah and Stiglitz (1986), evaluating the project is either organized as a hierarchy or as a polyarchy. Moreover, the principal decides whether an agent involved in the screening should be in charge of the subsequent implementation (integration) or a new agent (separation). Jost and Lammers (2010) find the principal to favor integration due to a rent-saving effect since then the agent in charge of implementation accepts a lower wage for the screening phase and nevertheless is sufficiently incentivized due to the prospect of gains for implementation. This rent-saving argument is strongest for the first agent in line of the evaluation as he screens all the projects. Additionally, Jost and Lammers (2010) find hierarchy to be superior to polyarchy since under the latter organizational form more projects reach the implementation phase which requires the principal to pay for more instances.

The second strand of literature originates in Holmström (1982/99) who formalized Fama (1980)'s idea of market - driven incentives, which is described as the prospect of future earnings bearing a disciplinary effect on agent's performance at present. Ever since, the benefit and downside of career concerns have been investigated. Gibbons and Murphy (1992) for instance find a combination of explicit and implicit incentives both theoretically to be optimal and empirically to be evident. Relatively speaking, implicit incentives should be strongest at a start of a career as then reaping the benefit of increased reputations is longest. Vice versa, the closer to retirement, the larger should be the explicit incentives. Suurmond et al. (2004) find within an adverse selection model that reputational concerns might be beneficial to welfare, because the intention for distinction enhances the incentives of high-typed agents. On the downside of career concerns are a tendency to herd, i.e. to ignore private information which conflicts with observed information. Scharfstein and Stein (1990) employ a two staged project choice model to show the incentive of the second agent to go along with the project choice of the first agent despite contrary valuable information. Career concerns prevent inefficient use of information as conflicting decisions put the agent at risk to bear the reputational cost of a failure alone. If two agents sequentially decide about a public project and the quality of information is endogenously determined, Swank and Visser (2008) find a tendency of the first agent to free ride on the second agent. Another source of inefficient use of information is analyzed in Prendergast and Stole (1996) who find a young professional to overvalue new information in order to show confidence and an experienced professional to undervalue new information in order not to destroy the market's inference from previous decision.

Our model captures both positive and negative effects of career concerns. On the positive side, the principal saves on payments as reputational concerns serve as substitutes for explicit incentives. On the negative side, career concerns put pressure on working in the second stage after a first stage success if the agent is in charge of both stages. This is because the first stage success is a strong signal for the agent's type being smart. But only a failure in one of the two stages, let the market infer that the project is characterized as difficult. This drawback of reputational concerns under integration is new.

The rest of the paper is organized as follows: The next section introduces the basic model including the timing of the game. Section 1.3 analyzes both organizational forms, separation and integration. Section 1.4 presents a discussion and section 1.5 concludes.

1.2 The Basic Model

Consider a two - staged decision model about a project with a R&D phase in stage one and a commercialization phase in stage two. Each stage might result in a success or in a failure. The outcome of stage $i \in \{1, 2\}$ is $E_i \in \{0, 1\}$ where 0 represents a failure and 1 represents a success. A successful R&D phase increases the success probability for the second stage. However, a failure in stage $i = 1$ can still result in a success in stage $i = 2$. The principal ultimately is interested in a success in stage two. The principal can hire an agent to exert costly but unobservable effort to increase the success probabilities in each stage. The benefit of effort depends on the agent's type who is equally likely either dumb (du) or smart (sm). No party involved knows about the type's realization, neither the agent himself nor the market. In addition to the effort and type dependence of the success probabilities, the project is also binary characterized. With the prior probability of p the project is *easy* and then assumed to be always successful in both stages even without any agent's effort exerted. For the remainder $1 - p$ of the projects, they are $difficult$ and then the probabilities heavily hinge on agent's type and effort. For difficult projects it is assumed that a dumb agent can never successfully perform the R&D phase, while a smart agent does so with probability 1_λ. This notation stands for an indicator function which relates to exerted effort. Thus, the indicator function is one if the smart agent exerts effort, saying the first stage results in a success for sure. If the agent does not exert effort, then the indicator function is zero and the success probability for the first stage is zero even though the agent is smart. Once the first phase is completed, the outcome is made public. The first-stage probability for success incorporates the stated assumptions, $\Pr(E_1 = 1) = p + \frac{1}{2}(1 - p) 1_\lambda$. Let $\Pr(E_1^e = 1)$ notate the term with $1_\lambda = 1$ and $\Pr(E_1^{ne} = 1)$ with $1_\lambda = 0$. If the agent does exert effort then $\Pr(E_1^e = 1) = p + \frac{1}{2}(1 - p)$ and $\Pr(E_1^{ne} = 1) = p$, otherwise. If no effort is exerted, the only way a project is still successful is when the project is easy. In addition to all easy projects the success probability is increased by the chance that a smart agent exerts effort on a difficult project and thus always succeeds. Remember that a dumb agent who exerts effort on a difficult project does always produce a failure. The following matrices summarize the first stage probability for success depending on both effort and type.

Stage 1		Type	
		sm	du
Effort	yes	1	p
	no	p	p

Conditionally on a success in the first stage, the probability of a second stage success for a difficult project is assumed to be $d + 1_{\mu_1}\mu_1$ if the performing agent is smart. For a first-stage failure the probability drops to $d + 1_{\mu_0}\mu_0$, presuming $\mu_1 > \mu_0$. Again, indicator functions are involved representing the effect of effort. For a dumb agent on the other hand the second stage success probabilities are assumed to be d for difficult projects irrespective of the outcome of the first stage and the level of effort in the second stage. The following matrix summarizes the success probabilities for the second stage conditionally on a success in the first stage.

Stage 2 after $E_1 = 1$		Type	
		sm	du
Effort	yes	$p + (1-p)(d + \mu_1)$	$p + (1-p)d$
	no	$p + (1-p)d$	$p + (1-p)d$

Recall that easy projects are always successful in both stages and hence a failure in the first stage concludes the project to be difficult. The success probabilities for the second stage conditionally on a failure, i.e. $E_1 = 0$, change accordingly.

Stage 2 after $E_1 = 0$		Type	
		sm	du
Effort	yes	$d + \mu_0$	d
	no	d	d

The probability that the project is easy after a first stage success is inferred using Bayes' theorem: $\Pr(easy|E_1 = 1) = \frac{\Pr(E_1=1|easy)}{\Pr(E_1=1)} \Pr(easy) = \frac{p}{p+\frac{1}{2}1_\lambda(1-p)}$. Analogously, a first stage success alters the probability of a difficult project to $\Pr(difficult|E_1 = 1) = \frac{\frac{1}{2}1_\lambda(1-p)}{p+\frac{1}{2}1_\lambda(1-p)}$. While the first stage success probability was treated irrespective of the organizational form, since separation and integration are identical if looked only at the first stage, this is no longer the case once the second stage enters the picture. The reason is that the market which initially holds the same information with respect to the agent's type, namely the prior, can updated its beliefs after stage one if the same agent is in charge of both stages. These posterior beliefs held by the market depend on the effort exerted. In equilibrium, the market's anticipation of the chosen effort levels and the agents choices about their effort must match. In case of separation, the outcome of the first stage has no influence on the assessment of the agent's type performing the second stage, as both agent's types are independently drawn. Consequently, the market's posterior belief remains unchanged and equals the prior probability. Things are quite different for integration, because the same agent is performing both stages. Consider the market beliefs that the agent is exerting effort in the first stage, then a first stage failure is only produced by a dumb agent. A success however, does not signal perfectly that the performing agent is smart as the project could be easy and then succeed always. In order to differentiate between the two organizational forms, let us denote $\Pr_i(\cdot)$ with $i = I, S$ for integration (I) and separation (S). The following conditional success probabilities capture all assumptions:

$$\Pr_S(E_2 = 1|E_1 = 1) = \frac{p}{p + \frac{1}{2}1_\lambda(1-p)} + \frac{\frac{1}{2}1_\lambda(1-p)\left(\frac{1}{2}(d + 1_{\mu_1}\mu_1) + \frac{1}{2}d\right)}{p + \frac{1}{2}1_\lambda(1-p)} \tag{1.1}$$

and

$$\Pr_I(E_2 = 1|E_1 = 1) = \frac{p}{p + \frac{1}{2}1_\lambda(1-p)} + \frac{\frac{1}{2}1_\lambda(1-p)}{p + \frac{1}{2}1_\lambda(1-p)}(d + 1_{\mu_1}\mu_1). \tag{1.2}$$

The difference between both expressions is kept in the last bracket considering the probability that the second stage is successful conditional on a difficult project and a first stage success. Under integration the market perfectly infers that the agent must be smart while under separation a new agent is in charge of the second stage.

Each agent endows no wealth and exhibits career concerns reflected in the posterior belief the market has with respect to his type. This posterior belief is weighted by a non-negative, commonly known scalar β. Moreover, the principal pays the agent a wage contingent on the outcomes of both stages and the agent bears the cost of effort. All components are added up. The principal hires either one agent for each stage (separation) or hires one agent performing both stages (integration). In case of a second-stage success she receives $V > 0$. For each situation the principal offers optimal contracts taking into account the agent's limited liability. The optimal organizational form is at the focus of our paper and analyzed in the next section.

The timing of the game is as follows:

$0.A$	$0.B$	1	2	3
nature chooses agent's and project's type	principal decides on organizational form	agent chooses effort for stage 1	agent chooses effort for stage 2	payments are made and posteriors are updated

In stage 0.A, nature draws the agent's and the project's type. Both realizations remain unknown to all parties. The principal then decides upon the organizational form and offers a contract to either one or two agents, respectively, in stage 0.B. Note that we assume that she is not able to make her choice dependent on the outcome of the first agent's work. Upon accepting the contract, the performing agent decides upon exerting effort in each stage. The outcome of stage 1 of the project is made public after stage 1 of the timeline. The second stage effort decision is contingent on the first stage outcome. Finally, the outcomes realizes in stage 3, the agent or both agents are paid as contractually arranged and the market updates all information via Bayesian Updating.

1.3 Main Results

Before the optimal contracts are derived and compared, the success probabilities under integration and separation are looked at more closely. Ex ante, the pair of events that both stages succeed is under integration

$$\Pr_I(E_2 = 1, E_1 = 1) = p + \frac{1}{2}\,(1-p)\,1_\lambda\,(d + 1_{\mu_1}\mu_1) \tag{1.3}$$

and under separation

$$\Pr_S(E_2 = 1, E_1 = 1) = p + \frac{1}{2}(1-p)\, 1_\lambda \left(d + \frac{1}{2} 1_{\mu_1}\mu_1\right). \tag{1.4}$$

For both it holds that all easy projects are fully captured and moreover, both expressions equalize if effort is not exerted in both stages. The benefit of integration realizes after a first stage success while a first stage failure benefits separation. Upon effort exerted, only a dumb agent produces a failure in the first stage. In case of integration the dumb agent then also performs the second stage while for separation the second agent could still be smart. This is also seen in the ex ante probabilities of the pair of events that the first stage fails but nevertheless the second stage succeeds, i.e.:

$$\Pr_I(E_2 = 1, E_1 = 0) = (1-p)\left(\frac{1}{2}(1 - 1_\lambda)(d + 1_{\mu_0}\mu_0) + \frac{1}{2}d\right) \tag{1.5}$$

and

$$\Pr_S(E_2 = 1, E_1 = 0) = (1-p)\left(1 - \frac{1}{2}1_\lambda\right)\left(d + \frac{1}{2}1_{\mu_0}\mu_0\right). \tag{1.6}$$

Considering $1_\lambda = 1$, the benefit of separation is revealed, i.e. $\Pr_I(E_2 = 1, E_1^e = 0) = \frac{1}{2}(1-p)\, d$ and $\Pr_S(E_2 = 1, E_1^e = 0) = \frac{1}{2}(1-p)\left(d + \frac{1}{2}1_{\mu_0}\mu_0\right)$. The success probability is larger under separation as the second agent could be smart while under integration the agent is knowingly dumb. If no effort is exerted in the first stage, then both expressions equal.

As the principal is primarily interested in the second stage success, it is important to notice which benefit dominates. The answer to this question is found in the assumption that a successful R&D phase increases the second stage success probabilities. Put differently, $\Pr_I(E_2 = 1) - \Pr_S(E_2 = 1) = \frac{1}{4}(1-p)\, 1_\lambda\, (1_{\mu_1}\mu_1 - 1_{\mu_0}\mu_0)$[5] is non-negative due to the assumption $\mu_1 > \mu_0$.

[5]The following expressions are used: $\Pr_I(E_2 = 1) = \Pr_I(E_2 = 1, E_1 = 1) + \Pr_I(E_2 = 1, E_1 = 0)$ and $\Pr_S(E_2 = 1) = \Pr_S(E_2 = 1, E_1 = 1) + \Pr_S(E_2 = 1, E_1 = 0)$.

This is the well-known rent-saving effect described in the introduction.[6]
The principal offers one or two agents a contract which specifies the payment contingent on the outcomes of both stages. As each agent is bearing the cost of effort entirely and the exerted effort is uncontractible, the principal faces a classical moral hazard problem. The principal copes with this by offering contracts which fulfill the participation and incentive constraint for each agent. The incentive constraint for one of the two stages ensures the agent to exert effort in this stage. If the principal does not seek the agent to exert some effort in one stage, then the corresponding incentive constraint does not need to be met by the optimal contract. The following three effort profiles are analyzed.[7] Let S_1 denote the effort profile under separation when the principal wants the agent in the first stage and the agent in the second stage to exert effort irrespective of the first stage outcome. S_0 denotes the profile under separation, when the agent in the first stage exerts effort and in the second stage only after a success in first stage. Once the principal chooses integration, then only one effort profile is considered. Denote I the profile which incentivizes the agent in the first and in the second stage after a first stage success. Incentivizing the agent in the second stage after a failure is not optimal, as a failure in the first stage with exerted effort is only feasibly made by a dumb agent. As effort by dumb agents does not increase the success probabilities but just produces costs, the second stage incentive constraint under integration and after a first stage failure is not binding. For each organizational form and effort profile the optimal contract is derived.

[6] Compare Laux (2001) and Schmitz (2005).

[7] We assume that all other potential effort profiles are unprofitable for the principal. In particular, the principal always wants the agent in the first stage to exert effort.

Separation

The principal hires agent A to work in the first stage and agent B in the second. She offers both agents a separate contract. The incentive constraint of agent A requires that exerting effort grants a higher expected utility than shirking, i.e.:

$$\Pr(E_1^e = 1)u_1^A + \Pr(E_1^e = 0)u_0^A - c \geq \Pr(E_1^{ne} = 1)u_1^A + \Pr(E_1^{ne} = 0)u_0^A \quad (1.7)$$

using $u_i^A = w_i^A + \beta * E[sm_A|E_1^e = i]$ with $i = 0, 1$ as Bernoulli utility functions[8] once the outcome of the first stage was a success or failure respectively. The benefit of effort must offset the cost of effort c, as shirking would be optimal otherwise. The principal takes the agent's A incentive constraint into account when setting the contingent payments w_i^A. Since it is never optimal to incentivize a failure in the first stage, the principal optimally sets $w_0^A = 0$. Inserting the utilities, recognizing the maximizing behavior by the principal and making use of the relation $\Pr(E_1^e = 1) - \Pr(E_1^{ne} = 1) = -\left(\Pr(E_1^e = 0) - \Pr(E_1^{ne} = 0)\right)$ reduces the constraint to

$$w_1^A \geq \frac{c}{\Pr(E_1^e = 1) - \Pr(E_1^{ne} = 1)} - \beta\left(E[sm_A|E_1^e = 1] - E[sm_A|E_1^e = 0]\right) \quad (1.8)$$

The higher the cost of effort c, the higher the contingent payment w_1^A in order to fulfill the incentive constraint. The higher the benefit of effort, i.e. the difference $\Pr(E_1^e = 1) - \Pr(E_1^{ne} = 1)$, the lower is w_1^A. The effect of career concerns depend on the sign of $E[sm_A|E_1^e = 1] - E[sm_A|E_1^e = 0]$, as the weight β is assumed to be non-negative. The difference is non-negative since a success in the first stage is more likely made by a smart agent and vice versa, a failure is more likely made by a dumb agent. In total, the career concerns by the agent A allow the principal to offer a lower contingent payment w_1^A.

[8] Compare Mas-Colell et al. (1995, p. 184) for a definition.

Thus, the principal internalizes the agent's desire to be perceived favorably by the market by offering reduced contingent payments. Due to limited liability however, it must hold $w_1^A \geq 0$ even if the agent exhibits extreme strong career concerns such that the incentive constraint would have been met with a negative w_1^A.

Agent B is offered a contract before the first stage starts and hence has two incentive constraints for each outcome of the first stage. Yet again, exerting effort must grant a higher utility than shirking conditionally on either outcome in the first stage. Agent B always expects that agent A has exerted effort. Consider a success in the first stage, then the constraint requires:

$$\begin{aligned}\Pr_S(E_2^e = 1|E_1^e = 1)u_{11}^B + \Pr_S(E_2^e = 0|E_1^e = 1)u_{10}^B - c \geq \\ \Pr_S(E_2^{ne} = 1|E_1^e = 1)u_{11}^B + \Pr_S(E_2^{ne} = 0|E_1^e = 1)u_{10}^B\end{aligned} \tag{1.9}$$

Since the organizational form matters with respect to the success probabilities in the second stage, all probabilities run the index S. Applying the same logic as above, the constraint reduces to:

$$\begin{aligned}w_{11}^B \geq \frac{c}{\Pr_S(E_2^e = 1|E_1^e = 1) - \Pr_S(E_2^{ne} = 1|E_1^e = 1)} \\ -\beta\left(\Pr(sm_B|E_2^e = 1, E_1 = 1) - \Pr(sm_B|E_2^e = 0, E_1 = 1)\right)\end{aligned} \tag{1.10}$$

Similarly, in case of a first-stage failure the constraint is given by:

$$\begin{aligned}\Pr_S(E_2^e = 1|E_1^e = 0)u_{01}^B + \Pr_S(E_2^e = 0|E_1^e = 0)u_{00}^B - c \geq \\ \Pr_S(E_2^{ne} = 1|E_1^e = 0)u_{01}^B + \Pr_S(E_2^{ne} = 0|E_1^e = 0)u_{00}^B\end{aligned} \tag{1.11}$$

which results in:

$$w_{01}^{B} \geq \frac{c}{\Pr_S(E_2^e = 1|E_1^e = 0) - \Pr_S(E_2^{ne} = 1|E_1^e = 0)} \tag{1.12}$$
$$-\beta \left(\Pr(sm_B|E_2 = 1, E_1 = 0) - \Pr(sm_B|E_2 = 0\,, E_1 = 0)\right)$$

Each constraint ensures the optimality of exerting costly effort by the agent. It holds for separation that each constraint is easier fulfilled for an increased career concern parameter β. While we assume that the principal always desires the agent in the first stage to exert effort, she has the choice concerning the second stage. For example, she might prefer to leave a second stage effort aside after a first stage failure. In this case, the third incentive constraint dealing with exactly this situation is not binding. If she desires the agent B to be incentivized irrespective of the first stage outcome, then she must ensure to meet all three constraints by setting the contingent payments accordingly. Comparing the principal's utility under separation between incentivizing the agent B only after a success $\left(U_{S_0}^{P}\right)$ and irrespective of the first stage outcome $\left(U_{S_1}^{P}\right)$ reveals the benefit of both effort profiles:

$$U_{S_1}^{P} = \left(\Pr_S(E_2^e = 1, E_1^e = 1) + \Pr_S(E_2^e = 1, E_1^e = 0)\right) V - \Pr(E_1^e = 1) w_1^A \tag{1.13}$$
$$- \Pr_S(E_2^e = 1, E_1^e = 1) w_{11}^{B} - \Pr_S(E_2^e = 1, E_1^e = 0) w_{01}^{B}$$

and

$$U_{S_0}^{P} = \left(\Pr_S(E_2^e = 1, E_1^e = 1) + \Pr_S(E_2^{ne} = 1, E_1^e = 0)\right) V - \Pr(E_1^e = 1) w_1^A \tag{1.14}$$
$$- \Pr_S(E_2^e = 1, E_1^e = 1) w_{11}^{B}.$$

The contingent payments are set equal to their corresponding constraint and are the same in both utility functions. Consequently, the benefit of incentivizing agent B even after a first-stage failure is a higher success probability of the second stage, i.e. $\Pr_S(E_2^e = 1, E_1^e = 0) - \Pr_S(E_2^{ne} = 1, E_1^e = 0) \geq 0$. The benefit of incentivizing agent B only after a first stage success however is the cost saving of $\Pr_S(E_2^e = 1, E_1^e = 0)w_{01}^B$.

Integration

Instead of hiring two agents, the principal offers only agent C to work in both stages. Incentivizing the agent in both stages after a first stage failure can not be optimal due to the assumption made. If the agent has exerted effort and still produces a failure in the first stage, the principal perfectly infers the agent's type, namely dumb. Therefore, exerting effort in the second stage is of no use because only smart agent's effort benefits the success probabilities. Moreover, the principal is only interested in a second stage success and hence has no intention to award any other outcome than two consecutive successes w_{11}^C. Thus, she sets $w_{10}^C = w_{01}^C = w_{00}^C = 0$. The following inequality captures the second stage incentive constraint[9] of agent C:

$$\begin{aligned}\Pr_I(E_2^e = 1|E_1^e = 1)u_{11}^C + \Pr_I(E_2^e = 0|E_1^e = 1)u_{10}^C - c \geq \\ \Pr_I(E_2^{ne} = 1|E_1^e = 1)u_{11}^C + \Pr_I(E_2^{ne} = 0|E_1^e = 1)u_{10}^C\end{aligned} \tag{1.15}$$

Analogously to w_{11}^B, the inequality is equivalent to:

$$\begin{aligned}w_{11}^C \geq \frac{c}{\Pr_I(E_2^e = 1|E_1^e = 1) - \Pr_I(E_2^{ne} = 1|E_1^e = 1)} \\ -\beta\left(\Pr(sm_C|E_2^e = 1, E_1^e = 1) - \Pr(sm_C|E_2^e = 0, E_1^e = 1)\right)\end{aligned} \tag{1.16}$$

This constraint shows the negative consequence of career concerns. Since the market perfectly infers the agent to be smart if the first stage was a success and the second failed, i.e. $\Pr(sm_C|E_2^e = 0, E_1^e = 1) = 1$ and so the term in

[9] Due to our focus we assume a minimum share of easy projects, i.e. $p \geq \frac{\mu_1 - 2d}{2d + 3\mu_1}$, in order to ensure that the second-stage incentive constraint is stricter than the first-stage constraint. This issue is further discussed in section 1.4.

brackets is negative. The larger the career concern parameter β, the higher the required contingent payment to ensure the agent to be incentivized in the second stage after a first stage failure.

Installing the organizational form of integration and offering agent C the minimum contingent payment such that he is incentivized to exert effort in the first stage and in the second stage after a first stage success, the utility of the principal amounts to:

$$
\begin{aligned}
U_I^P = &\Big(\Pr_I(E_2^e = 1, E_1^e = 1) + \Pr_I(E_2^{ne} = 1, E_1^e = 0)\Big)\, V \\
&- \Pr_I(E_2^e = 1, E_1^e = 1) w_{11}^C
\end{aligned}
\tag{1.17}
$$

Comparing Separation and Integration

Which organizational form is installed is for the principal to decide. Three different constellations of organizational form and effort profile are to be considered, namely S_1, S_0 and I with the latter being the principal's choice to hire agent C for both stages and incentivizing the first stage and the second stage after a first stage success only. All three utilities of the principal are compared at once using indifference curves as auxiliary functions in (V, β) space.[10] Three auxiliary functions are constructed, let us denote $U_{S_1S_0}$ the curve indicating all non-negative combinations of (V, β) where the principal is indifferent between choosing the organizational form of separation and either S_1 or S_0. Analogously, denote U_{IS_1} and U_{IS_0} being the collection of (V, β) combinations where the principal is indifferent between choosing integration I and S_1 or S_0, respectively. Based on these functions, the following proposition states the results.

[10] Due to the complexity of the problem, no analytical solution was found.

Proposition 1 *In absence of any career concerns, i.e.* $\beta = 0$*, then the following relation holds:* $U_{S_1S_0} \geq 0 \geq U_{IS_0} \geq U_{IS_1}$*. Concerning the slopes of the three indifference curves, it holds:* $\frac{\partial U_{IS_1}}{\partial \beta} \geq \frac{\partial U_{IS_0}}{\partial \beta} \geq 0 \geq \frac{\partial U_{S_1S_0}}{\partial \beta}$*.*

The intuition of Proposition 1 is most easily explained at Figure 1.1. The positive quadrant of (V, β) space is sectioned into three regions showing for which combinations of (V, β) which constellation of organizational form and effort profile is optimal.

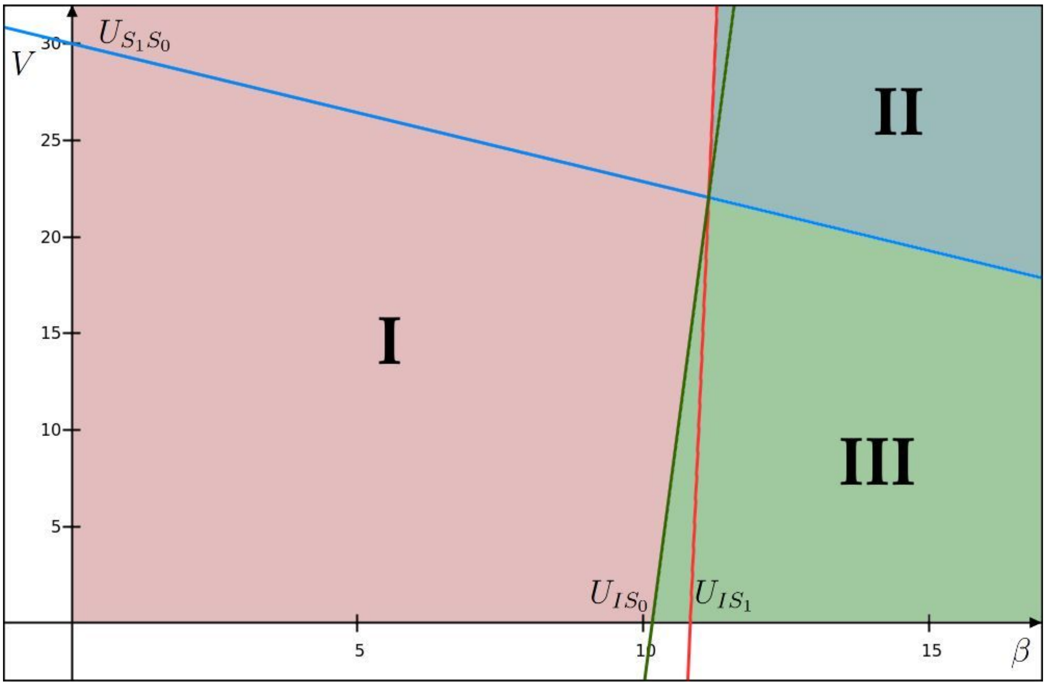

Figure 1.1: Indifference curves using $p = \frac{1}{2}$; $c = 1$; $d = \frac{2}{10}$; $\mu_1 = \frac{3}{10}$ and $\mu_0 = \frac{2}{10}$.

The beauty of using indifference curves is its clear separation of the entire positive quadrant of the (V, β) plane. For example, any point above $U_{S_1S_0}$ (blue line) reveals the optimality of S_1 over S_0. Vice versa, any point below the optimality of S_0 over S_1. And as the name suggests, for any point on this function the principal is indifferent between choosing S_1 or S_0.

Observe three patterns. Firstly, the rent-saving effect of integration which is illustrated by the negative intersection of the V axis of both U_{IS_0} (green line) and U_{IS_1}(red line). The effect is described by the first part of Proposition 1. Both indifference curves involving I have negative signs, i.e. in absence of any reputational concerns the hiring costs of agent C are lower than for agent A and B, irrespective of the incentivized effort profile under separation. Secondly, the downside of reputational concerns under integration is present which is seen by the positive slope. Only $U_{S_1S_0}$ has a positive intersection of the V axis capturing the fact that the cost of effort is increased if agent B is also incentivized after a first stage failure. Moreover, $U_{S_1S_0}$ has a negative slope because under S_1 agent B has more chances to show off and consequently is willing to exert effort for a lower contingent payment, which in turn is benefiting the principal. This effect is captured by the second part of Proposition 1. The third observation is the intersection point of all three indifference curves. Due to the nature of these three auxiliary functions this unique combination is predictable as long as two indifference curves intersect. In this case, the third indifference curve must necessarily lie on the intersection point.

The principal's choice depends on all three indifference curves, because a combination might for instance lie above $U_{S_1S_0}$, suggesting S_1 is the optimal choice, but at the same time also lie above U_{IS_1}. In this case, the principal prefers I over S_1. The differently coloured areas I, II and III depict all combinations for which either one organizational form and effort profile is dominating. In area I, integration I is best, in area II, S_1 is best and in area III, S_0 is best.

So far, the participation constraint of the principal has not been taking into account. If the principal's expected utility is negative however, the optimal choice is to leave the project uninvestigated and not to hire any agent. Incorporating the three participation constraint ($U_{S_1} \geq 0$ (beige line) , $U_{S_0} \geq 0$ (purple line) and $U_I \geq 0$ (turquoise line)) into Figure 1.1 leads to Figure 1.2, which depicts the optimal choices of the principal. Region X summarizes all combinations of V and β for which the optimal choice is not to have investigated the project at all. Both areas I and III from figure one are truncated by all combinations which do not meet the participation constraint and transform to XI and XIII, respectively. Any combination within region XI results in integration as being the principal's optimal choice. For area XIII, the best choice is separation and not to incentivize the agent after a first-stage failure, i.e. S_0. Region II and XII coincide, as all combinations are fulfilling all three participation constraints, in particular ($U_{S_1} \geq 0$). In this area, as before, S_1 is the optimal choice.

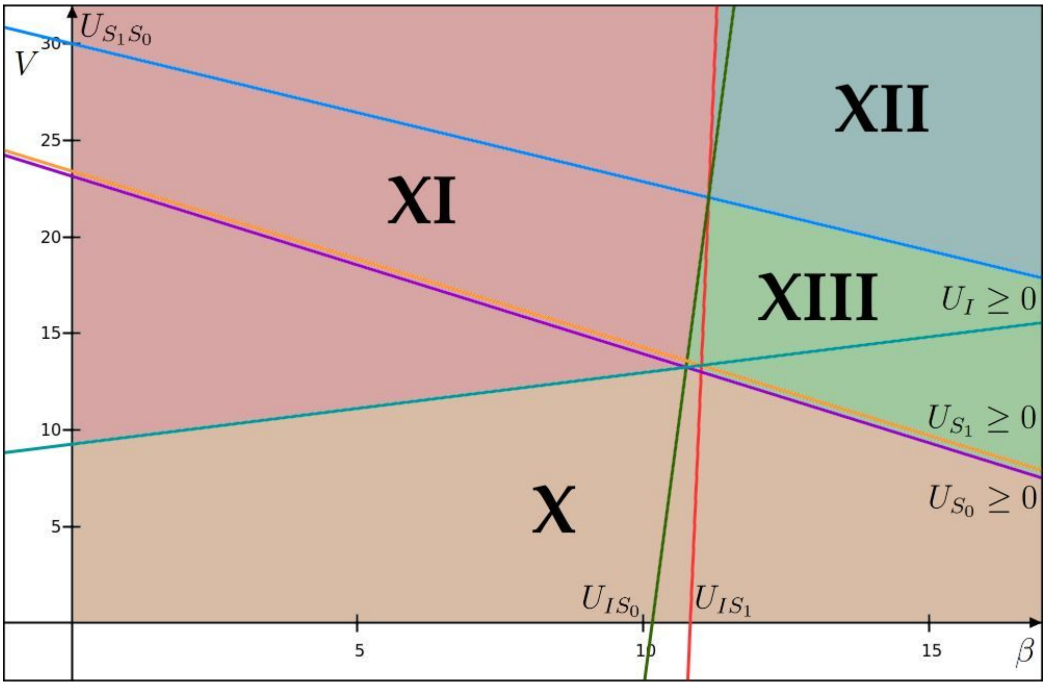

Figure 1.2: S_1 is the optimal choice in region XII, S_0 in region XIII. Integration I is preferred in region XI, while region X represents all combinations for which the principal prefers not to hire any agent.

1.4 Discussion

The shirking incentive of agent C due to career concerns crucially hinges on the assumption that the project is either of easy or of difficult type. Consider there were only easy projects, then beside being economically non sense, the principal has no intention to hire any agent and the question integration vs. separation is obsolete. The case when all projects are difficult, however, has already been part of research for instance in Schmitz (2005). In this case, agent C has stronger incentives to exert effort in the second stage after a first stage success as two successes are the best signal of ability, given there are no easy projects around.[11] In practice, having projects of different degrees of difficulty seems to be realistic in many situations. Smircich and Cheeser (1981) find superiors and subordinates often disagreeing on the level of difficulty which supports the assumption in our model of keeping the project's difficulty unknown to all parties.

Our result of agent's C shirking incentive does not only need projects of different type, but also a minimum share of easy projects, i.e. $p \geq \frac{\mu_1 - 2d}{2d + 3\mu_1}$. If the share of difficult projects is sufficiently large, the incentive constraint in the first stage is stronger than the second stage incentive constraint. Remember, the incentivized effort profile is still such that only after a first stage success effort is desired. The higher the share of difficult projects, the more likely the agent exerts effort in the first stage in vain. Investigating the impact of the first constraint follows Schmitz (2005)'s work who finds an incentive to shirk once the principal prefers the agent to exerted effort irrespective of the first stage outcome, in particular after a first stage failure. Anticipating the decreased success probabilities for the second stage, going along with increased payments, the agent tends to shirk in the first stage. This

[11] In general, the larger the share of difficult projects, the higher the posterior belief after two success, i.e. $\frac{\partial \Pr(sm_C | E_2^e = 1, E_1^e = 1)}{\partial p} = -\frac{(d+\mu_1)}{(2p+((d+\mu_1))(1-p))^2} < 0$.

tendency is met by the principal offering a higher wage. Our model extends Schmitz (2005)'s model to career concerned agents and thus this argument is present. Consider the incentive constraint of agent C for the first stage given the principal desires the agent only to exert effort in the second stage after a success:

$$\begin{aligned}\left(w_{11}^{C}\right)^{1^{st}} \geq \; & \frac{c + c\left(\Pr(E_1^e = 1) - \Pr(E_1^{ne} = 1)\right)}{\Pr_I(E_2^e = 1, E_1^e = 1) - \Pr_I(E_2^e = 1, E_1^{ne} = 1)} \\ & - \beta \Pr_I(sm|E_2^e = 1, E_1^e = 1) \\ -\beta \Pr_I(sm|E_2^e = 0, E_1^e = 1) & \frac{\Pr_I(E_2^e = 0, E_1^e = 1) - \Pr_I(E_2^e = 0, E_1^{ne} = 1)}{\Pr_I(E_2^e = 1, E_1^e = 1) - \Pr_I(E_2^e = 1, E_1^{ne} = 1)}\end{aligned} \tag{1.18}$$

Remark that $\Pr_I(sm|E_2^e = 0, E_1^e = 1) = 1$ and $\Pr_I(E_2^e = 0, E_1^{ne} = 1) = 0$ holds. Two important insights are highlighted. Firstly, for $\beta = 0$ and only difficult projects, i.e. $p = 0$, the inequality $\left(w_{11}^{C}\right)^{1^{st}}$ is stronger than w_{11}^{C} which reproduces Schmitz (2005)'s finding. Secondly, the effect of career concerns is negative, as the term in brackets translate to $\frac{1}{2}\frac{p+(1-p)(d+\mu_1)}{p+(1-p)\left(d+\frac{1}{2}\mu_1\right)} + \frac{(1-d-\mu_1)}{(d+\mu_1)}$. Since the effect of career concerns points likewise to separation, namely negative with respect to the contingent payment, the more interesting case arises once the second stage incentive constraint is binding, which is the focus of our model.

1.5 Conclusion

Should a principal hire one or two agents for a two-staged project in case of career concerned agents? We answered this question studying a two-staged hidden action model with risk neutral agents exhibiting both limited liability and career concerns. We find a well-known rent-saving effect as an advantage of hiring one agent who is in control for both stages. Incentives for the first stage can then be saved as the agent would not miss the chance to receive the second stage rent. This argument does not hold for the organizational form of separation, as then each agent needs to be incentivized in stage one and two, respectively. Additionally, we find a novel shirking effect under integration. This effect is due to reputational concerns and the type space of considered projects. The best posterior belief the market can hold with respect to the agent's type is given after a first-stage success and a second stage failure. The case vice versa is eliminated by assumption, i.e. the principal always desires effort in the first stage and then it is assumed that a failure is a perfect signal of a dumb agent. The impact of a failure is securing that the project type is difficult. As for only those kinds of projects, the agent can prove himself. Since the principal is purely interested in a second stage success, the offered contingent payment for a failure is zero. In order to incentivize the agent to exert effort after a first stage success, the payment must offset the agent's career concerns. Consequently, reputational concerns have negative implications under integration. At the same time, these concerns benefit the principal under separation. Each agent only works one stage and a success is always superior to a failure in terms of career concerns. The offered contingent payment is lowered the heavier the agent considers his career concerns. Explicit incentives are substituted by implicit incentives.

1.6 Appendix

1.6.1 Preliminaries

Posterior Beliefs

The posterior beliefs the market holds are derived using Bayes' theorem for a given effort profile, i.e.
$\Pr(sm_C|E_2^e = 1, E_1^e = 1) = \frac{\Pr_I(E_2^e=1,E_1^e=1|sm_C)}{\Pr_I\left(E_2^e=1,E_1^e=1\right)} \Pr\left(sm_C\right) = \frac{p+(1-p)(d+\mu_1)}{p+\frac{1}{2}(1-p)(d+\mu_1)} \frac{1}{2}$ and
$\Pr(sm_C|E_2^{ne} = 0, E_1^e = 1) = \frac{\Pr_I(E_2^{ne}=0,E_1^e=1|sm_C)}{\Pr_I\left(E_2^{ne}=0,E_1^e=1\right)} \Pr\left(sm_C\right) = \frac{(1-p)(1-d)}{\frac{1}{2}(1-p)(1-d)} \frac{1}{2} = 1$

using $\Pr_I\left(E_2^{ne}=0, E_1^e=1\right)=\frac{1}{2}(1-p)\, 1_\lambda\left(1-d-1_{\mu_1} \mu_1\right)$. The posterior belief for agent B are given by:
$\Pr(sm_B | E_2^e=1, E_1^e=1)=\frac{p+\frac{1}{2}(1-p)(d+\mu_1)}{p+\frac{1}{2}(1-p)\left(d+\frac{1}{2} \mu_1\right)} \frac{1}{2}$ and $\Pr(sm_B | E_2^e=0, E_1^e=1)=\frac{(1-d-\mu_1)}{\left(1-d-\frac{1}{2} \mu_1\right)} \frac{1}{2}$ using $\Pr_S(E_2=0, E_1=1)=\frac{1}{2}(1-p)\, 1_\lambda\left(1-d-\frac{1}{2} 1_{\mu_1} \mu_1\right)$. Analogously, it holds $\Pr(sm_B | E_2^e=1, E_1^e=0)=\frac{(d+\mu_0)}{\left(d+\frac{1}{2} \mu_0\right)} \frac{1}{2}$ and $\Pr(sm_B | E_2=0\,, E_1=0)=\frac{(1-d-\mu_0)}{\left(1-d-\frac{1}{2} \mu_0\right)} \frac{1}{2}$. The posterior beliefs for agent A are also based on both stage outcomes due to the assumptions on project type. For each pair of events the market holds posterior beliefs: $\Pr(sm_A | E_2=1, E_1^e=1)=\frac{p+(1-p)\left(d+1_{\mu_1} \mu_1 \frac{1}{2}\right)}{p+(1-p) \frac{1}{2}\left(d+1_{\mu_1} \mu_1 \frac{1}{2}\right)} \frac{1}{2}$ and $\Pr(sm_A | E_2=0, E_1^e=1)=\frac{\left(1-d-1_{\mu_1} \mu_1 \frac{1}{2}\right)}{\frac{1}{2}\left(1-d-1_{\mu_1} \mu_1 \frac{1}{2}\right)} \frac{1}{2}=1$. In case of a first stage failure, the market holds the following beliefs with respect to agent's A type: $\Pr(sm_A | E_2=1, E_1^e=0)=\frac{(1-1)\left(d+1_{\mu_0} \mu_0 \frac{1}{2}\right)}{\left(1-\frac{1}{2}\right)\left(d+1_{\mu_0} \mu_0 \frac{1}{2}\right)} \frac{1}{2}=0$ and $\Pr(sm_A | E_2=0, E_1^e=0)=\frac{(1-1)\left(1-d-1_{\mu_0} \mu_0 \frac{1}{2}\right)}{\left(1-\frac{1}{2}\right)\left(1-d-1_{\mu_0} \mu_0 \frac{1}{2}\right)} \frac{1}{2}=0$.

Incentive constraints

Considering the incentive constraint of agent C as described by (1.16) results in: $w_{11}^C \geq \frac{\left(p+\frac{1}{2}(1-p)\right)}{\frac{1}{2}(1-p) \mu_1} c+\beta \frac{p}{2\left(p+\frac{1}{2}(1-p)(d+\mu_1)\right)}$. Considering the incentive constraint of agent B as in (1.10) and (1.12) the following expressions are derived: $w_{11}^B \geq \frac{(1+p)}{(1-p)} \frac{2c}{\mu_1}-\frac{1}{2} \beta\left(\frac{p+\frac{1}{2}(1-p)(d+\mu_1)}{p+\frac{1}{2}(1-p)\left(d+\frac{1}{2} \mu_1\right)}-\frac{(1-d-\mu_1)}{\left(1-d-\mu_1 \frac{1}{2}\right)}\right)$ and $w_{01}^B \geq 2 \frac{c}{\mu_0}-\frac{1}{2} \beta\left(\frac{(d+\mu_0)}{\left(d+\mu_0 \frac{1}{2}\right)}-\frac{(1-d-\mu_0)}{\left(1-d-\mu_0 \frac{1}{2}\right)}\right)$. Using (1.8) the constraint considers the expected posterior belief, thus
$E[sm_A | E_1^e=1]=\Pr_S(E_2=1 | E_1^e=1) \Pr(sm_A | E_2=1, E_1^e=1)+\Pr_S(E_2=0 | E_1^e=1) \Pr(sm_A | E_2=0, E_1^e=1)$ and $E[sm_i | E_1^e=0]=\Pr_S(E_2=1 | E_1^e=0) \Pr(sm_A | E_2=1, E_1^e=0)+\Pr_S(E_2=0 | E_1^e=0) \Pr(sm_A | E_2=0\,, E_1^e=0)$. Inserting the conditionally probabilities reduces the difference substantially, i.e. $E[sm_A | E_1^e=1]-E[sm_A | E_1^e=0]=\frac{1}{(1+p)}$. The constraint then equals: $w_1^A \geq \frac{2c}{(1-p)}-\frac{1}{(1+p)} \beta$.

Utility of principal

The utility of the principal depends on her choice about the organizational form and the effort profile. Using both (1.13) and (1.14), and setting all contingent payments optimally grants her the following utility:
$U_{S_1}^P = \left(p + (1-p)\left(d + \frac{1}{4}\left(\mu_1 + \mu_0\right)\right)\right) V - \frac{1}{2}\left(1+p\right)\left(\frac{2c}{(1-p)} - \frac{1}{(1+p)}\beta\right)$
$- \left(p + (1-p)\frac{1}{2}\left(d + \frac{1}{2}\mu_1\right)\right)\left(\frac{(1+p)}{(1-p)}\frac{2c}{\mu_1} - \frac{1}{2}\beta\left(\frac{p+\frac{1}{2}(1-p)(d+\mu_1)}{p+\frac{1}{2}(1-p)\left(d+\frac{1}{2}\mu_1\right)} - \frac{(1-d-\mu_1)}{\left(1-d-\mu_1\frac{1}{2}\right)}\right)\right)$
$- (1-p)\left(1-\frac{1}{2}\right)\left(d + \mu_0\frac{1}{2}\right)\left(2\frac{c}{\mu_0} - \frac{1}{2}\beta\left(\frac{(d+\mu_0)}{\left(d+\mu_0\frac{1}{2}\right)} - \frac{(1-d-\mu_0)}{\left(1-d-\mu_0\frac{1}{2}\right)}\right)\right).$
$U_{S_0}^P = \left(p + (1-p)\left(d + \frac{1}{4}\mu_1\right)\right) V - \frac{1}{2}\left(1+p\right)\left(\frac{2c}{(1-p)} - \frac{1}{(1+p)}\beta\right)$
$- \left(p + (1-p)\frac{1}{2}\left(d + \frac{1}{2}\mu_1\right)\right)\left(\frac{(1+p)}{(1-p)}\frac{2c}{\mu_1} - \frac{1}{2}\beta\left(\frac{p+\frac{1}{2}(1-p)(d+\mu_1)}{p+\frac{1}{2}(1-p)\left(d+\frac{1}{2}\mu_1\right)} - \frac{(1-d-\mu_1)}{\left(1-d-\mu_1\frac{1}{2}\right)}\right)\right).$
In case of integration the utility of the principal amounts to:
$U_I^P = \left(p + (1-p)\left(d + \frac{1}{2}\mu_1\right)\right) V - \frac{\left(p+\frac{1}{2}(1-p)(d+\mu_1)\right)}{\mu_1}\frac{(1+p)}{(1-p)}c - \frac{1}{2}p\beta.$

Indifference curves

Based on these utilities, the three indifference curves are derived:
$U_{S_1S_0} : U_{S_1} \geq U_{S_0} \Leftrightarrow V \geq \frac{1}{\mu_0}\left(\frac{4\left(d+\frac{1}{2}\mu_0\right)}{\mu_0}c - \frac{\mu_0}{2-2d-\mu_0}\beta\right).$
$U_{IS_1} : U_I \geq U_{S_1} \Leftrightarrow$
$V \geq -\frac{1}{(\mu_1-\mu_0)}\left(2\frac{(1+p)}{(1-p)}\frac{d(1-p)+2p+2\mu_1}{\mu_1(1-p)} + 4\frac{\left(d+\mu_0\frac{1}{2}\right)}{\mu_0}\right)c +$
$\frac{1}{(\mu_1-\mu_0)}\left(\frac{(1+p)}{(1-p)}\frac{(4-4d-\mu_1)}{(2-2d-\mu_1)} + \frac{\mu_0}{(2-2d-\mu_0)}\right)\beta.$
$U_{IS_0} : U_I \geq U_{S_0} \Leftrightarrow V \geq \frac{(1+p)}{(1-p)}\left(-\frac{d(1-p)+2p+2\mu_1}{\frac{1}{2}(\mu_1)^2(1-p)}c + \frac{1}{\mu_1}\frac{(4-4d-\mu_1)}{(2-2d-\mu_1)}\beta\right).$

1.6.2 Proof of Proposition 1

The first part of this proposition translates to
$\frac{4\left(d+\frac{1}{2}\mu_0\right)}{(\mu_0)^2}c \geq 0 \geq -\frac{(1+p)}{(1-p)}\frac{d(1-p)+2p+2\mu_1}{\frac{1}{2}(\mu_1)^2(1-p)}c \geq -2\frac{(1+p)}{(1-p)}\frac{d(1-p)+2p+2\mu_1}{\mu_1(1-p)}\frac{c}{(\mu_1-\mu_0)}$
$-4\frac{\left(d+\mu_0\frac{1}{2}\right)}{\mu_0}\frac{c}{(\mu_1-\mu_0)}$. The first two relations directly are seen to be true due to the assumptions made upon the parameters. The third inequality needs careful investigation. It is equivalent to: $2\frac{(1+p)(d(1-p)+2p+2\mu_1)}{(1-p)\mu_1(1-p)}\left(\frac{1}{(\mu_1)} - \frac{1}{(\mu_1-\mu_0)}\right) \leq$

$\frac{1}{(\mu_1-\mu_0)}\left(4\frac{\left(d+\mu_0\frac{1}{2}\right)}{\mu_0}\right)$. Left-hand side is negative and right-hand side is non-negative. The second part of this proposition translates to $\left(\frac{(1+p)}{(1-p)}\frac{(4-4d-\mu_1)}{(2-2d-\mu_1)}+\frac{\mu_0}{(2-2d-\mu_0)}\right)\frac{1}{(\mu_1-\mu_0)} \geq \frac{(1+p)}{(1-p)}\frac{(4-4d-\mu_1)}{(2-2d-\mu_1)}\frac{1}{\mu_1} \geq 0 \geq -\left(\frac{\mu_0}{2-2d-\mu_0}\right)\frac{1}{\mu_0}$. The first inequality is equivalent to $\Leftrightarrow \frac{(1+p)}{(1-p)}\frac{(4-4d-\mu_1)}{(2-2d-\mu_1)}\frac{1}{\mu_1}+\frac{1}{(2-2d-\mu_0)} \geq 0$. Both summands are non-negative. The second and third inequality are true due to assumptions made. **q.e.d.**

1.6.3 Numerical Evaluation

Inserting the following numbers: $p=\frac{1}{2}$, $c=1$, $d=\frac{2}{10}$, $\mu_1=\frac{3}{10}$ and $\mu_0=\frac{2}{10}$ leads to the following three numerical versions of the indifference curves: $U_{S_1S_0} \rightarrow \; V \geq 30-\frac{5}{7}\beta$, $U_{IS_1} \rightarrow \; V \geq \frac{6220}{91}\beta-740$ and $U_{IS_0} \rightarrow \; V \geq \frac{290}{13}\beta-\frac{680}{3}$. These are used in Figure 1.1. Based on the same numbers, the three participation constraints are derived which are used in Figure 1.2: $U^P_{S_1} \geq 0 \rightarrow V \geq \frac{1240}{53}-\frac{4400}{4823}\beta$, $U^P_{S_0} \geq 0 \rightarrow V \geq \frac{1180}{51}-\frac{610}{663}\beta$ and $U^P_I \geq 0 \rightarrow V \geq \frac{10}{27}\beta+\frac{250}{27}$.

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Essay 2: Transparency and Career Concerned Experts

Kevin Remmy *

Abstract

A risk neutral principal hires a career conscious agent for a project choice decision between a risky and a safe alternative. Depending on the underlying state of the world each project might be ex post optimal. The agent can undertake unobservable effort to receive better information which project to implement. In full awareness of the incentive scheme, the principal decides upfront about the level of information the market has access to. Either the market only knows the project outcome (intransparent case) or additionally knows which project had been implemented (transparent case). The principal might favor transparency, even when it comes at a cost, due to increased incentives to exert effort which are induced by a superior inference capability by the market with respect to the agent's type.

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2.1 Introduction

The importance for most people to be favorably perceived by others has been vastly studied ever since the seminal paper by Holmström (1982/99) who formalized Fama (1980)'s idea.[1] Particularly present is the desire within a business environment, as climbing up the career ladder usually involves being beneficially perceived by the job market. The term "career concerns" has become standard for these considerations. Our model joins the line of research focusing on agents exhibiting career concerns for expertise, i.e. the ability of the agents to gather and process information. Consider facing a project choice between a risky and a safe alternative of which each might be ex post optimal depending on the underlying state of the world. A career-conscious agent can undertake some costly effort to be in a better position informational-wise, before deciding which project to implement. Within that branch of research one question naturally arises: what is optimal degree of information an outside party has access to? We focus on two different degrees of information: intransparency and transparency. If an outside party only receives the outcome of the project as information, then it is called intransparent. Transparency on the other hand allows the outside party additional information, namely which of the two projects has been implemented. Prat (2005) argues that transparency might result in inefficient use of information due to a distortional effect towards actions likely made by smart agents, which are not necessarily efficient.[2] In contrast, Bar-Isaac (2012) finds that transparency benefits the incentives to exert effort. However, his result depends on an exogenously given risk premium which distorts the career concerned agents project choice.

Our model contributes to the career concern literature by showing that transparency boosts the information gathering incentives even in the absence of

[1] For an overview, see for instance Prendergast (1999).

[2] See also Brandenburger and Polak (1996) and Levy (2007) for similar arguments.

any risk premium. On the broader perspective, our findings add to the ongoing debate whether or not career concerns have positive consequences.[3] The intuition of our result is linked to market's inference with respect to the agent's type. Transparency allows the market to infer from more relevant information compared to intransparency. Anticipating the better chances to prove himself, the agent has increased incentives to exert effort.

Milbourn et al. (2001) were the first to extend the career concerns literature to situations with agents whose unobservable, but costly effort supports processing and gathering information, instead of adding to productivity. Hence, these models endogenize expertise, i.e. the quality of relevant information a decision maker has access to. Milbourn et al. (2001) find an over investment[4] in information by a career conscious agent. They link good projects to the type space such that observing an implementation of a good project let the market believe a rather more capable agent was at work. Milbourn et al. (2001) assume that only implementation allows for inference by the market. This one-sided distortion leads to the result of over investment in information by decreasing the probability of implementing bad projects. Their result thus crucially hinges on the assumption that rejecting serves as a safe haven for the agent in terms of his reputation.[5] Since rejecting does not allow the market to update any information, the agent does not face the risk of a reputational loss.

Suurmond et al. (2004) alter the information gathering mechanism such that a safe haven is no longer necessary for the results. They find that

[3]For instance, within a sequential setting Scharfstein and Stein (1990) find career concerned agents to ignore valuable private information in order not to appear different to the other agents in terms of private information. Gibbons and Murphy (1992) on the other hand propose an optimal contract which includes implicit incentives based on career concerns.

[4]The costs are borne by the firm in their model, instead of being carried by the agent.

[5]As a matter of fact, if the market always observes the correctness of the agents choice, then the posterior belief must equal the prior belief of the agent's type as exerting effort does not per se increase the probability of having a good project.

reputational concerns by the agent are welfare enhancing if the agent does not know his type. If the agent however knows his type, then the effect of reputational concerns on welfare is less clear. While a dumb agent optimally undertakes inefficient actions to mimic a smart agent, the smart agent has enlarged incentives to exert efficient effort to distinguish himself from the dumb agent. Which effect dominates, depends on the specific parameters.

Most closely related to our model is Bar-Isaac (2012) who also finds a positive effect of transparency on the incentives to exert effort. However, an exogenously given risk premium is required. We find an inventive boosting consequence of transparency even in the absence of such a risk premium. The intuition behind this result is found in the differences in modeling the safe alternative. In Bar-Isaac (2012) the safe project serves as a safe haven with respect to the project outcome and to the beliefs about the agent's type. The project outcome is fixed and the beliefs are not updated, i.e. the posterior beliefs equal the priors. Having the outcome of a safe project independent of the underlying state seems quite plausible, the assumption, however, that choosing the safe project does not carry any relevant information appears to be far too rigid. One consequence of this safe haven is the absence of an innate effect of transparency. As defined by the degree of information the market has access to, transparency allows the market to be sure about the agent's implementation decision. This additional information though, is not relevant due to the characteristics of a safe haven. In our model the agent's choice to implement the safe alternative does indeed carry some relevant information about the agent's type. Hence, transparency is inherently present in our model and augments the information gathering incentives. The reason why choosing the safe alternative reveals some information about the agent's type is found in the way exerting effort works. While in Bar-Isaac (2012) exerting effort supports the decision which of the two risky project to implement, leaving aside the safe action, our model incorporates the safe action such that exerting effort directs to either, the risky or the safe alternative. The rest of the paper is organized as follows: The next section introduces the basic model including the timing of the game. Section 2.3 analyzes the effect of transparency on the effort incentives. Section 2.4 presents a discussion and section 2.5 concludes.

2.2 The Basic Model

A risk neutral principal delegates a project choice decision to a risk neutral agent who exhibits career concerns. The choice is between two projects, (1) and (2). Let $x \in X$ denote the project outcome which potentially depends on the state of the world. There exist two equally likely states, S_1 and S_2. For project (1) we assume the expected project outcome to depend on the underlying state of the world, while for project (2) the expected outcome is irrespective of the realized state. For this reason, project (1) is declared as risky and project (2) as safe. Which project to implement is for the agent to decide. He can investigate the projects by exerting some costly effort before the decision. The agent receives a signal s_i with $i = 1, 2$ indicating either underlying state. The quality of the signal depends on both, the level of effort and the agent's type. The agent is either smart (sm) with probability $\alpha \in (0, 1)$ or dumb (du) with probability $1 - \alpha$. No one, not even the agent himself, knows his type. We assume that the signal perfectly indicates which state occurred if the agent is smart and informed. The probability of being informed is captured by $\pi(e) \in [0, 1]$ with $\frac{\partial \pi(e)}{\partial e} > 0$ and $\frac{\partial^2 \pi(e)}{(\partial e)^2} < 0$, using the exerted effort level as its argument. With probability $1 - \pi(e)$ the agent is uninformed and the signal then is assumed to carry pure noise. A dumb agent is assumed to be always uninformed, hence his received signal is pure noise even if he has exerted effort. The cost of effort is $c(e) \in [0, \infty)$ with $\frac{\partial c(e)}{\partial e} > 0$ and $\frac{\partial^2 c(e)}{(\partial e)^2} > 0$. The employed information gathering process has been introduced by Suurmond et al. (2004) and is summarized by the conditional probability of a state occurring given a signal: $\Pr(S_1|s_1) = \alpha\left(\pi(e) + (1-\pi(e))\,\frac{1}{2}\right) + (1-\alpha)\,\frac{1}{2} = \frac{1}{2}(1+\alpha\pi(e))$. Due to symmetry of state and signal, it holds $\Pr(S_1|s_1) = \Pr(S_2|s_2)$. Similarly, the conditional probabilities for conflicting state and signal are derived: $\Pr(S_1|s_2) = \frac{1}{2}(1-\alpha\pi(e)) = \Pr(S_2|s_1)$. While the information process is identical to the approach by Suurmond et al. (2004), the payoff structure of the two projects is not. The set of outcomes has four elements, $X = \{-\frac{1}{2}, 0, \frac{1}{2}, 1\}$. The following matrices capture the outcomes depending on the state of the world:

Project (1)		State S_1	State S_2
Lottery	$\frac{1}{2}$	1	$\frac{1}{2}$
	$\frac{1}{2}$	0	$-\frac{1}{2}$

Project (2)		State S_1	State S_2
Lottery	$\frac{1}{2}$	$\frac{1}{2}$	0
	$\frac{1}{2}$	0	$\frac{1}{2}$

Consider choosing project (1) when the underlying state is S_2, then the equally likely outcomes $x = \frac{1}{2}$ or $x = -\frac{1}{2}$ might occur. The payoff structure contains four defining properties with $E_{(i)}[x]$ using $i = 1, 2$ representing the expected outcome x of implementing either project (1) or project (2).

(i) $E_{(1)}[x] = E_{(2)}[x] \geq 0$

(ii) $E_{(1)}[x|\ S_1] > E_{(2)}[x|\ S_1]$ & $E_{(2)}[x|\ S_2] > E_{(1)}[x|\ S_2]$

(iii) $E_{(1)}[x|\ S_1] - E_{(1)}[x|\ S_2] \neq 0$ & $E_{(2)}[x|\ S_1] - E_{(2)}[x|\ S_2] = 0$

(iv) $\exists\ x \in X$ which occurs in both projects

The properties (i) and (ii) ensure non existence of a dominating project by having the same non-negative unconditional outcome (i) but depending on the state one project is superior to the other (ii). The third property says that the expected conditional outcome of one specific project might depend on the underlying state. This property allows for distinction between risky and safe projects. Project (1) is declared as risky due to the expected outcome's reliance on the underlying state. A direct implication of the properties is that $E_{(1)}[x|\ S_1] > E_{(1)}[x] > E_{(1)}[x|\ S_2]$. For the same reason is project (2) seen as safe, $E_{(2)}[x|\ S_1] = E_{(2)}[x] = E_{(2)}[x|\ S_2]$. The fourth property expresses the fact that information about the realized outcome does not serve as a perfect signal for the implemented project, namely the outcomes $x = 0$ and $x = \frac{1}{2}$ do not allow for perfect inference. The imperfect inference of the outcome lays the path for the concept of transparency, as it represents the degree of information the market has access to. The market is aware of the payoff structure, but cannot distinguish between the two projects in case of intransparency. The only observation for the market is the realization of X. For a transparent organization the market gets to know which project had been implemented in addition to the observed outcome. The principal knows which project has been chosen. Making the organization transparent comes at a cost $k > 0$. Both environments would lead to the same, if not for property (iv). The inherent fair lottery over outcomes is necessary for the feasibility of the properties within this two state - two project situation.[6] The results of this paper hinge on these four properties and by no means on the quantitative character of the payoff structure. Thus, any structure fulfilling these properties leads to the same qualitative results.

The agent exhibits career concerns. He weighs his career concerns with the scalar $\lambda \geq 0$. For career concerns being meaningful, a smart agent should act

[6] To see this consider the following payoff structure without a lottery:

$$(1)\ \begin{array}{cc} S_1 & S_2 \\ V & W \end{array} \qquad (2)\ \begin{array}{cc} S_1 & S_2 \\ X & Y \end{array} \ \text{with } V, W, X, Y \in \mathbb{R}$$

The third property requires $Y = X$. The fourth requires that at least one outcome appears in both, so take for instance $V = X$. As a result of the first property it must then hold $W = X$. Hence, all four outcomes are the same. Besides being a trivial payoff structure, the second property is not fulfilled.

differently than a dumb agent, at least on the margin. The second property of the payoff structure serves exactly this purpose. Given the state S_1, project (1) is the right and project (2) the wrong choice. Vice versa it holds for the state S_2. Due to the information gathering process a right choice is more likely made by a smart agent.

Ultimately, the principal is interested in the outcome of the project. In order to increase the probability of implementing the correct project, she lets an agent exert effort to investigate the projects. The principal anticipates that the agent welcomes this opportunity to show off and gain the project's outcome, and hence she demands a price p_i with $i = I, T$ paid by the agent.[7] Her utility is then given by $U^P(p_i) = p_i - 1_k k$ with 1_k being an indicator function, i.e. $1_k = 1$ if the principal decides for transparency, and $1_k = 0$ otherwise. The principal bears entirely the cost of making the organization transparent.

The utility function of the agent contains four components additively: $U^A(e) = E[x] + \lambda E[sm] - p_i - c(e)$. Firstly, the expected project outcome. The second component captures the career concerns. Thirdly, the agent has to pay the price p_i to the principal in order to be able to investigate the project. The price depends on the environment, as the principal might ask different prices for each. The fourth part of the agent's utility function shows that the agent bears entirely the costs of exerting unobservable effort.

[7] The considered contract is called a "sell-the-shop" contract and has become standard within our assumptions made, namely both the agent and the principal are risk neutral and the agent does not suffer any limited liability.

The timing of the game is as follows:

0	1	2	3	4	5
nature chooses type of agent	principal decides on transparency and p_i	agent accepts contract	agent chooses effort	agent decides on project	payments are made and posteriors are updated

At stage 0, nature determines the agent's type which is not made public to any party. At stage 1 the principal decides which degree of information the market shall have access to. Either the market only receives the information of the project outcome (intransparency) or it also knows which project the agent has chosen (transparency). Then, the principal optimally chooses the price p_i which the agent needs to pay if he accepts the contract in stage 2. The agent decides on his effort at stage 3. In stage 4, he receives a signal and then chooses which project to implement. At the very end, the random variable realizes, payments are made accordingly and the market updates via Bayesian updating.

2.3 Main Results

The Perfect Bayesian Nash Equilibrium concept is applied. The market processes all accessible information via Bayesian updating. The considered strategy of the agent is to exert effort and to follow his signal. The strategy of the agent is applied to evaluate the distribution function over four different values of the outcome x. Consider for instance the realization of the outcome $x = 0$. Given the agent's strategy this outcome might occur following either signal. In case of $s = s_1$, the signal must be true and in case of $s = s_2$ the outcome $x = 0$ might occur in both states. Taking the inherent lottery into account, the probability of the outcome is derived: $\Pr(x=0) = \Pr(s_1)\Pr(S_1|s_1)\frac{1}{2} + \Pr(s_2)\left(\Pr(S_2|s_2)\frac{1}{2} + \Pr(S_1|s_2)\frac{1}{2}\right) = \frac{1}{8}(3+\alpha\pi(e))$. Analogously, the probabilities of the three other outcomes are derived, given the assumed agent's strategy to exert effort and to follow his signal: $\Pr(x=\frac{1}{2}) = \frac{1}{8}(3-\alpha\pi(e))$, $\Pr(x=1) = \frac{1}{8}(1+\alpha\pi(e))$, $\Pr(x=-\frac{1}{2}) = \frac{1}{8}(1-\alpha\pi(e))$.

Career concerns are captured by the posterior belief of the market with respect to type. The market uses any relevant and accessible information to infer on agent's type. The outcome x is always made public and hence used. The additional information about which project has been implemented is only available if the principal had decided to make the organization transparent. Consequently, the posterior beliefs the market holds are potentially different for transparency and intransparency. Let $\Pr(sm|\overline{x})$ denote the posterior belief that the agent is smart conditionally on the outcome $x=\overline{x}$. Similarily, $\Pr(sm|\overline{x},\overline{s})$ denotes the posterior belief that the agent is smart conditionally on the outcome $x=\overline{x}$ and the signal $s=\overline{s}$. Note, conditioning on signals is equivalent to using the implemented projects. The reason lies in the assumed strategy of the agent who always follows his signal. Beliefs are highest if the agent did the right choice and moreover, the market is able to distinguish whether or not the agent did the right choice, i.e. $\Pr(sm|\ x=1) = \frac{\Pr(x=1|sm)\Pr(sm)}{\Pr(x=1)} = \frac{\frac{1}{8}(1+\pi(\hat{e}))}{\frac{1}{8}(1+\alpha\pi(\hat{e}))}\alpha$. The worst on the contrary is having knowingly implemented the wrong project. In between are the prior and those beliefs where the market cannot perfectly infer. The following relation holds:

$$\Pr(sm|\ x=1) \geq \Pr(sm) \geq \Pr(sm|\ x=-\frac{1}{2})$$

$$\Leftrightarrow$$

$$\frac{\frac{1}{8}(1+\pi(\hat{e}))}{\frac{1}{8}(1+\alpha\pi(\hat{e}))}\alpha \geq \alpha \geq \frac{\frac{1}{8}(1-\pi(\hat{e}))}{\frac{1}{8}(1-\alpha\pi(\hat{e}))}\alpha \tag{2.1}$$

In equilibrium the market holds a correct belief about the exerted effort level e. Therefore, the notation $\hat{e}$ is used for any posterior belief and, hence for any Bernoulli utility function[8] $u(\cdot)$ which determines the utility of having implemented one of the two projects for a given state. The notation $u^i_{(1)}(\hat{e}|S_1)$ with $i = I, T$ is used to represent the agent's utility once project (1) has been implemented and the underlying state of the world is $S = S_1$. For instance, consider the case that the principal has chosen intransparency, then the outcomes $x = 1$ or $x = 0$ can occur. Both outcomes are equally likely, uses by the market and balanced by the career concern parameter λ, i.e. $u^I_{(1)}(\hat{e}|S_1) = E_{(1)}[x|S_1] + \lambda\left(\frac{1}{2}\Pr(sm|x=1) + \frac{1}{2}\Pr(sm|x=0)\right) = \frac{1}{2} + \frac{1}{2}\alpha\lambda\left(\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))} + \frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)$. Due to the proposed strategy by the agent to follow his signal, the probability of reaching $u^I_{(1)}(\hat{e}|S_1)$ equals the joint probability that the signal $s = s_1$ and the state $S = S_1$ occurred, hence $\Pr(S_1, s_1) = \Pr(s_1)\Pr(S_1|s_1)$. The agent's von-Neumann-Morgenstern utility function $U(\cdot)$ captures the reaching probabilities and the Bernoulli utilities:

$$\begin{aligned} U^A_i(e) &= \Pr(S_1, s_1)u^i_{(1)}(\hat{e}|S_1) + \Pr(S_2, s_1)\, u^i_{(1)}(\hat{e}|S_2) \\ &+ \Pr(S_1, s_2)u^i_{(2)}(\hat{e}|S_1) + \Pr(S_2, s_2)\, u^i_{(2)}(\hat{e}|S_2) - c(e) \end{aligned} \tag{2.2}$$

The agent maximizes $U^i(e)$ over effort e.[9] Due to the second part of the third property of the payoff structure the utility is independent of the underlying state when the safe project is chosen, as expected profit is the same for both states. Since the outcomes for both states are symmetric, the posterior beliefs with respect to type have to be the same.[10] This observation holds for both environments and reduces the considered maximization problem sub-

[8]Contrary to von-Neumann-Morgenstern utility function, the Bernoulli utility function is not defined over a lottery but over sure events. Compare p.184 in Mas-Colell et al. (1995)

[9]The utility function is concave in effort e due to the assumption made on $\pi(e)$ and $c(e)$. Moreover, parameters are such that exerting at least some positive effort is optimal.

[10]Note that neither the principal nor the market are able to observe the state. While the principal can always observe the outcome and the project choice, the market can observe the outcome and in case of transparency also the project choice.

stantially, given $u^i_{(2)}(\hat{e}|S_1) = u^i_{(2)}(\hat{e}|S_2) = u^i_{(2)}(\hat{e})$. Inserting the binary signal structure and the information gathering information process accordingly leads to:

$$U^i(e) = \frac{1}{4}\left(u^i_{(1)}(\hat{e}|S_1) + u^i_{(1)}(\hat{e}|S_2)\right) + \frac{1}{4}\alpha\pi(e)\left(u^i_{(1)}(\hat{e}|S_1) - u^i_{(1)}(\hat{e}|S_2)\right) \quad (2.3)$$
$$+ \frac{1}{2}u^i_{(2)}(\hat{e}) - c(e)$$

So far, we have assumed that the agent exerts effort, receives and follows his signal. Before the optimal effort level is derived, the next lemma establishes the second part of the proposed strategy.

Lemma 1 *If the agent exerts some effort, then it is optimal for him to follow his signal.*

Proof. See the Appendix. ■

The intuition for this result is found in the assumed combination of risk neutrality and information gathering process. Given some effort, the informativeness of the signal is not trivial, i.e. $\Pr(S_1|s_1) > \frac{1}{2}$, compared to the prior $\Pr(S_1) = \frac{1}{2}$. Hence, following his signal is then beneficial on average. If no effort is exerted however, the signal carries only noise, compare $\Pr(S_1|s_1) = \Pr(S_1|s_2) = \frac{1}{2}$. The equilibrium effort level e^*_i is defined by setting the first-order condition (FOC) of (2.3) to zero. Any perfect Bayesian Nash Equilibrium requires that the market holds a correct belief about the agent's effort, i.e. $\hat{e} = e^*_i$.

$$\frac{1}{4}\alpha\frac{\partial\pi(e)}{\partial e}|_{e=e^*_i}\left(u^i_{(1)}(\hat{e}|S_1) - u^i_{(1)}(\hat{e}|S_2)\right) = \frac{\partial c(e)}{\partial e}|_{e=e^*_i} \quad (2.4)$$

The benefit of effort is driven by the difference between the Bernoulli utilities of correctly and wrongly implementing the risky project $\triangle^i = u^i_{(1)}(\hat{e}|S_1) -$

$u^i_{(1)}(\hat{e}|S_2)$. The next lemma establishes the relation between this difference and the implied optimal effort level.

Lemma 2 *The effort level e_i^* implied by (2.4) increases if $\triangle^i$ increases.*
Proof. *See the Appendix.* ■

One immediate consequence of Lemma 2 concerns the decision about transparency. When the principal decides about transparency, she anticipates the effect on the agent's effort choice. Using Lemma 2, investigating the impact boils down to its impact on the difference $\triangle^i$. Let $e_I^*(e_T^*)$ denote the optimal effort the agent chooses under intransparency (transparency). The next lemma shows a positive effect of transparency on the agent's effort decision.

Lemma 3 *The agent exerts more effort when the principal chooses transparency, i.e. $e_T^* \geq e_I^*$.*
Proof. *See the Appendix.* ■

The intuition for Lemma 3 is found in the increased inference capability of the market under transparency. That is why transparency enhances the incentives to gather information. The market can tell for any outcome whether the agent did the right or wrong decision. The market is not able to say this for the outcomes $x = 0$ and $x = \frac{1}{2}$ if the principal has decided for intransparency, as both outcomes might occur in both projects. The posterior beliefs for these two outcomes are in between the best (right decision) and worst (wrong decision) and thus the difference $\triangle^I$ is not as large as $\triangle^T$. The principal's decision about transparency takes the consequences on the agent's decision to exert effort into consideration. The following proposition describes the unique equilibrium of this game.

Proposition 1 *Assume $\frac{1}{8}\alpha\left(\pi\left(e_T^*\right) - \pi\left(e_I^*\right)\right) \geq c\left(e_T^*\right) - c\left(e_I^*\right) + k$, then the principal chooses transparency. The agent chooses e_T^* such that the corresponding equation (2.4) holds, i.e. $\frac{1}{4}\alpha\frac{\partial\pi(e)}{\partial e}\left(u^T_{(1)}(\hat{e}|S_1) - u^T_{(1)}(\hat{e}|S_2)\right) = \frac{\partial c(e)}{\partial e}$.*

And he follows his signal. In case of $c(e_T^*) - c(e_I^*) + k \geq \frac{1}{8}\alpha(\pi(e_T^*) - \pi(e_I^*))$, *the principal chooses intransparency. The agent chooses* e_I^* *such that the equation* $\frac{1}{4}\alpha\frac{\partial\pi(e)}{\partial e}\left(u_{(1)}^I(\hat{e}|S_1) - u_{(1)}^I(\hat{e}|S_2)\right) = \frac{\partial c(e)}{\partial e}$ *holds and follows his signal. In both cases the market holds beliefs about the agent's type which are derived using Bayesian updating.*

Proof. *See the Appendix.* ■

The result of Proposition 1 is counterbalancing the positive and negative effects of transparency. The benefit of transparency is the enhanced inference capability of the market which in turn incentivizes the agent to increased effort. By exerting effort the agent shifts the probability of making the right decision and preventing from implementing the wrong one. In equilibrium however, the agent cannot outplay the market in terms of his type, because he has no informational advantage to draw on. Neither he nor the market knows his type. The drawback of transparency is the cost to transform the organization into a transparent one. From the principal's perspective, the decision to choose between transparency and intransparency is in favor of the latter if the cost of increased effort and the cost of transparency k outweigh the increased success probabilities due to the higher level of effort.

2.4 Discussion

The realization of the agent's type remains unknown throughout the entire game. As a result, no adverse selection problem is present. Even though the agent's effort is unobservable, a moral hazard problem is not an issue either. The optimal effort levels chosen by the agent are first-best effort levels which is a standard result if "sell-the-Shop" contracts are available. Incorporating this fact, the same results are derived by modeling only the agent leaving the principal aside. In this modification the agent receives the project outcome and works for the principal in her best interests. For example, Suurmond et al. (2004), Milbourn et al. (2001) and Bar-Isaac (2012) do not model the principal explicitly due to the same reason. Nevertheless, we found that the decision about the degree of transparency suits a principal much better than an agent.

Our results depend crucially on the assumption that the market is not in a position to tell which project has been implemented unless a.) the principal wants it to or b.) the outcome allows for a perfect inference to the project choice. The concept of transparency makes only sense given this assumption. In practice however, this assumption appears not to be too harsh, since firms are often very keen on holding back precise information from any outside party.

We assumed a cost attached to making an organization transparent. In practice, this assumption is easily met since transparency is modeled such that additional information is gathered and made accessible to the market. Both steps require resources which are not needed in case of intransparency. In theory, this assumption is necessary to ensure a trade-off between transparency and intransparency, as in absence of any cost, i.e. $k = 0$, the inequality of Proposition 1 in favor of transparency reduces to $\frac{1}{8}\alpha\left(\pi\left(e_T^*\right) - \pi\left(e_I^*\right)\right) \geq c\left(e_T^*\right) - c\left(e_I^*\right)$. This inequality is always met due to the concavity of the agent's utility function.

2.5 Conclusion

Our project choice model considers the consequences of transparency on the incentives to exert effort by a career conscious agent and sheds light on the optimality of transparency. We find that transparency has a positive effect on the agent's incentive to exert unobservable, but costly effort. Since transparency causes a better inference capability by the market due to more relevant and accessible information. This in turn boosts a career concerned agent as making a right project choice improves his reputation significantly. Likewise, making a wrong project choice results in a severe damage of his reputation. The principal then prefers transparency to intransparency whenever the costs of transparency are offset by its benefits.

2.6 Appendix

2.6.1 Preliminaries

For an intransparent environment, the agent's utility of choosing project (1) in presence of S_1 is $u^I_{(1)}(\hat{e}|S_1) = \frac{1}{2} + \frac{1}{2}\alpha\lambda\left(\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))} + \frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)$ and in presence of S_2: $u^I_{(1)}(\hat{e}|S_2) = \frac{1}{2}\alpha\lambda\left(\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))} + \frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\right)$. If the agent chooses to implement project (2), then his utility is irrespective of the state: $u^I_{(2)}(\hat{e}) = \frac{1}{4} + \frac{1}{2}\alpha\lambda\left(\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))} + \frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)$. In case of transparency things are a bit more involved. If the agent chooses (1) upon receiving a truthful signal s_1 his utility is $u^T_{(1)}(e|S_1, s_1) = \frac{1}{2} + \alpha\lambda\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}$. Is the signal not truthful however, his utility is $u^T_{(1)}(e|S_2, s_1) = \alpha\lambda\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}$. Choosing (1) upon a signal s_2 the utilities change to $u^T_{(1)}(e|S_1, s_2) = \frac{1}{2} + \frac{1}{2}\alpha\lambda$ and $u^T_{(1)}(e|S_2, s_2) = \frac{1}{2}\alpha\lambda$. Does the agent decide to implement project (2), then his utilty is $u^T_{(2)}(e|s_1) = \frac{1}{4} + \frac{1}{2}\alpha\lambda\left(\frac{(1-\pi(e))}{(1-\alpha\pi(e))} + \frac{(1+\pi(e))}{(1+\alpha\pi(e))}\right)$ upon receiving s_1 and $u^T_{(2)}(e|s_2) = \frac{1}{4} + \alpha\lambda$ otherwise.

2.6.2 Proof of Lemma 1

Given $s = s_1$, choosing project (1) must grant higher utility than choosing (2). This must hold for both environments.

(i) $\Pr(S_1|s_1)u^I_{(1)}(\hat{e}|S_1) + \Pr(S_2|s_1)\, u^I_{(1)}(\hat{e}|S_2) \geq u^I_{(2)}(\hat{e})$ and

(ii) $\Pr(S_1|s_1)u^T_{(1)}(\hat{e}|S_1, s_1) + \Pr(S_2|s_1)\, u^T_{(1)}(\hat{e}|S_2, s_1) \geq u^T_{(2)}(\hat{e}|s_1)$ must hold.

Inserting the conditional probabilities and the Bernoulli utilities leads to:

(i) $\leftrightarrow \frac{1}{2}(1 + \alpha\pi(e))\left(\frac{1}{2} + \frac{1}{2}\alpha\lambda\left(\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))} + \frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)\right)$

$+\frac{1}{2}(1-\alpha\pi(e))\frac{1}{2}\alpha\lambda\left(\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}+\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\right)\geq\frac{1}{4}+\frac{1}{2}\alpha\lambda\left(\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}+\frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)$
(i) $\leftrightarrow \frac{\pi(e)}{\lambda}+\alpha\pi(e)\left(\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}+\frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}-\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}-\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\right)\geq$
$\left(\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}+\frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)-\left(\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}+\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\right)$
Inequality is fulfilled since right-hand side (RHS) is less than second summand of left-hand side (LHS) and first summand of LHS is positive.
(ii) $\leftrightarrow \frac{1}{2}(1+\alpha\pi(e))\left(\frac{1}{2}+\alpha\lambda\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}\right)+\frac{1}{2}(1-\alpha\pi(e))\left(\alpha\lambda\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\right)\geq$
$\frac{1}{4}+\frac{1}{2}\alpha\lambda\left(\frac{(1-\pi(e))}{(1-\alpha\pi(e))}+\frac{(1+\pi(e))}{(1+\alpha\pi(e))}\right)$
(ii) $\leftrightarrow \frac{\pi(e)}{2\lambda}+2\geq\left(\frac{(1-\pi(e))}{(1-\alpha\pi(e))}+\frac{(1+\pi(e))}{(1+\alpha\pi(e))}\right)$
Again, inequality is fulfilled since first summand of LHS is positive and second summand of LHS is larger than RHS.
Analogously, if the signal is $s=s_2$, choosing project (2) must be preferred to choosing project (1). This must hold for both environments:
(I) $u^I_{(2)}(\hat{e})\geq \Pr(S_1|s_2)u^I_{(1)}(\hat{e}|S_1)+\Pr(S_2|s_2)\,u^I_{(1)}(\hat{e}|S_2)$ and
(II) $u^T_{(2)}(e|s_2)\geq \Pr(S_1|s_2)u^T_{(1)}(\hat{e}|S_1,s_2)+\Pr(S_2|s_2)\,u^T_{(1)}(\hat{e}|S_2,s_2)$.
Inserting the conditional probabilities and the Bernoulli utilities leads to:
(I) $\leftrightarrow \frac{1}{4}+\frac{1}{2}\alpha\lambda\left(\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}+\frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)\geq$
$\frac{1}{2}(1-\alpha\pi(e))\left(\frac{1}{2}+\frac{1}{2}\alpha\lambda\left(\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}+\frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\right)\right)+$
$\frac{1}{2}(1+\alpha\pi(e))\left(\frac{1}{2}\alpha\lambda\left(\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}+\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\right)\right)$
(I) $\leftrightarrow \frac{8\alpha(1-\alpha)\pi(\hat{e})^2\left(5-\pi(\hat{e})^2\alpha^2\right)}{9+\pi(\hat{e})^4\alpha^4-10\pi(\hat{e})^2\alpha^2}\geq-\frac{\pi}{\lambda}$
LHS is positive and RHS is negative.
(II) $\leftrightarrow \frac{1}{4}+\alpha\lambda\geq\frac{1}{2}(1-\alpha\pi(e))\left(\frac{1}{2}+\frac{1}{2}\alpha\lambda\right)+\frac{1}{2}(1+\alpha\pi(e))\frac{1}{2}\alpha\lambda$
(II) $\leftrightarrow \alpha\lambda\geq-\frac{1}{2}\alpha\pi(e)$.
LHS is positive and RHS is negative, thus all four inequalities hold. **q.e.d.**

2.6.3 Proof of Lemma 2

Lemma 2 states that for $\triangle_1>\triangle_2\Rightarrow e^*_1>e^*_2$ and is proven by contradiction. Using (2.4) $\frac{1}{4}\alpha\frac{\partial\pi(e)}{\partial e}\triangle_j=\frac{\partial c(e)}{\partial e}$ with $\triangle_j=\left(u^i_{(1)}(\hat{e}|S_1)-u^i_{(1)}(\hat{e}|S_2)\right)$, let us define $e_1^*:\triangle_1=\frac{4\frac{\partial c(e)}{\partial e}|_{e=e_1^*}}{\alpha\frac{\partial \pi(e)}{\partial e}|_{e=e_1^*}}$ and $e_2^*:\triangle_2=\frac{4\frac{\partial c(e)}{\partial e}|_{e=e_2^*}}{\alpha\frac{\partial \pi(e)}{\partial e}|_{e=e_2^*}}$. Assume $\triangle_1>\triangle_2$, which is equivalent to $\frac{\frac{\partial \pi(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial \pi(e)}{\partial e}|_{e=e_1^*}}>\frac{\frac{\partial c(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial c(e)}{\partial e}|_{e=e_1^*}}$ and presume that $e_2^*>e_1^*$ holds. Then this leads to $\frac{\partial c(e)}{\partial e}|_{e=e_2^*}>\frac{\partial c(e)}{\partial e}|_{e=e_1^*}$ and $\frac{\partial \pi(e)}{\partial e}|_{e=e_1^*}>\frac{\partial \pi(e)}{\partial e}|_{e=e_2^*}$, thus $\frac{\frac{\partial \pi(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial \pi(e)}{\partial e}|_{e=e_1^*}}<1$ and $\frac{\frac{\partial c(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial c(e)}{\partial e}|_{e=e_1^*}}>1$ and results in a contradiction. Then presume $e_1^*=e_2^*$, then $\frac{\frac{\partial \pi(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial \pi(e)}{\partial e}|_{e=e_1^*}}=\frac{\frac{\partial c(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial c(e)}{\partial e}|_{e=e_1^*}}$, which leads to a contradiction as well. Leaves the third option that $e_1^*>e_2^*$ which leads to $\frac{\frac{\partial \pi(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial \pi(e)}{\partial e}|_{e=e_1^*}}>1$ and $\frac{\frac{\partial c(e)}{\partial e}|_{e=e_2^*}}{\frac{\partial c(e)}{\partial e}|_{e=e_1^*}}<1$. **q.e.d.**

2.6.4 Proof of Lemma 3

The equilibrium effort e_I^* fulfills $\frac{1}{8}\frac{\partial \pi(e)}{\partial e}\triangle_I=\frac{\partial c(e)}{\partial e}$ with the difference parameter $\triangle_I=\left(u^I_{(1)}(\hat{e}|S_1)-u^I_{(1)}(\hat{e}|S_2)\right)$ and e_T^* fulfills $\frac{1}{8}\frac{\partial \pi(e)}{\partial e}\triangle_T=\frac{\partial c(e)}{\partial e}$ with $\triangle_T=\left(u^T_{(1)}(\hat{e}|S_1,s_1)-u^T_{(1)}(\hat{e}|S_2,s_1)\right)$. Due to lemma 1, showing $\triangle_T\geq\triangle_I$ is sufficient. Considering the following differences for intransparency $u^I_{(1)}(\hat{e}|S_1)-u^I_{(1)}(\hat{e}|S_2)=\frac{1}{2}+\frac{1}{2}\alpha\lambda\left(\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}+\frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}-\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}-\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\right)$ and transparency $u^T_{(1)}(e|S_1,s_1)-u^T_{(1)}(e|S_2,s_1)=\frac{1}{2}+\alpha\lambda\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}-\alpha\lambda\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}$ allows for: $\triangle_T\geq\triangle_I\Leftrightarrow\frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}-\frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}>\frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}-\frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}\Leftrightarrow$ $9-\pi(\hat{e})^2\alpha^2>3\left(1-\pi(\hat{e})^2\alpha^2\right)$. **q.e.d.**

2.6.5 Proof of Proposition 1

Presume that the principal has decided to make the organization intransparent. Then she maximizes the price p_I taking into account the agent's incentive constraint. If the agent is indifferent then it is assumed that she participates and is incentivized. Consequently, the maximum price the agent would pay is: $p_I^*=U_I^A(e_I^*)-U_I^A(e=0)$. Analogously, p_T^* is derived for transparency: $p_T^*=U_T^A(e_T^*)-U_T^A(e=0)$. The principal then decides to make the costly transition to an transparent environment whenever her utility of transparency is larger than her utility of intranspareny, which is equivalent in our model to maximizing the social welfare. The sum of both, the agent's and the principal's utility equals the social welfare. The principal then prefers transparency whenever the following inequality holds: $U_T^A(e_T^*) + U_T^P(p_T^*) \geq U_I^A(e_I^*) + U_I^P(p_I^*)$. After inserting the utilities this inequality reduces to: $\frac{1}{4} + \alpha\lambda + \frac{1}{8}\alpha\pi(e_T^*) - p_T^* - c\left(e_T^*\right) + p_T^* - k \geq \frac{1}{4} + \alpha\lambda + \frac{1}{8}\alpha\pi(e_I^*) - p_I^* - c\left(e_I^*\right) + p_I^*$ $\Leftrightarrow \frac{1}{8}\alpha\left(\pi(e_T^*) - \pi(e_I^*)\right) \geq c\left(e_T^*\right) - c\left(e_I^*\right) + k$.

The last part contains the posterior beliefs held by the market, given the described strategy by the agent and the principal. For intransparency, the market holds the following: $\Pr(sm|x = -\frac{1}{2}) = \frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\alpha$, $\Pr(sm|x = 0) = \frac{(3+\pi(\hat{e}))}{(3+\alpha\pi(\hat{e}))}\alpha$, $\Pr(sm|x = \frac{1}{2}) = \frac{(3-\pi(\hat{e}))}{(3-\alpha\pi(\hat{e}))}\alpha$ and $\Pr(sm|x = 1) = \frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}\alpha$. For transparency, the following holds: $\Pr(sm|\ x = -\frac{1}{2}, s_1) = \Pr(sm|\ x = \frac{1}{2}, s_1)$ $= \frac{(1-\pi(\hat{e}))}{(1-\alpha\pi(\hat{e}))}\alpha$, $\Pr(sm|\ x = 0, s_1) = \Pr(sm|\ x = 1, s_1) = \frac{(1+\pi(\hat{e}))}{(1+\alpha\pi(\hat{e}))}\alpha$, $\Pr(sm|\ x = -\frac{1}{2}, s_2) = \Pr(sm|\ x = 1, s_2) = 0$ and $\Pr(sm|\ x = 0, s_2) = \Pr(sm|\ x = \frac{1}{2}, s_2)$ $= \frac{1}{2}$. **q.e.d.**

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Essay 3: Career Concerns for Experts using Hybrid Incentives

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Abstract

We extend the Career Concern literature on the interplay between explicit and implicit incentives by introducing a hybrid incentive which is at the same time contract-contingent and market-driven. Consider a principal hiring a career conscious agent to evaluate a project. The market gains information about the quality of the agent's decision only if the project is implemented unless the principal decides to double-check also rejected projects. Double-checking rejected projects does not undue the implementation decision but solely generates information about the correctness of the agents decision. Precisely, the probability of a double-check is contractually arranged but induction of effort is market-driven. The agent anticipates the additional information of the market and then optimally exerts effort. We find that this hybrid incentive is superior to a pure explicit incentive whenever the prior probability of implementing correctly is sufficiently high.

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3.1 Introduction

The analysis of incentives for individuals has been one of the major research fields in principal agent theory in the last decades.[1] Inducing intended behavior by setting incentives appropriately forms the core of the theory, which sharply distinguishes between explicit, contract-contingent and implicit, market-driven incentives. While the explicit incentives are precisely set by the party writing the contract (principal), implicit incentives are not. Following Fama (1980) and Holmström (1982/99) these incentives are enforced by a perfectly competitive labor market (for agents) ensuring paying wages at the level of their expected productivity. The prospect of high compensation in the future disciplines the agent's present performance. Ever since Gibbons and Murphy (1992), the interplay between these two types of incentives has been of particular interest. They find implicit incentives are more effective at early stages and explicit ones at later stages. The closer to retirement, the less attractive are implicit incentives due to a shorter period of time benefiting from an increased reputation.

Our model contributes to the literature by introducing a hybrid incentive which is at the same time contract-contingent but also market-driven. Consider a risk-neutral principal who hires a career conscious agent to decide about implementation of a project. The agent is also risk-neutral and his liability is limited. If the project is executed then all parties get to know whether or not implementation was the right decision. If the project has been rejected, however, nobody gains information with respect to the quality of the agent's evaluation, unless the principal double-checks the rejected projects at the end of the game. Double-checking is costly to the principal and has no further consequence than to generate the information whether or not the agent's decision to reject was right. Noteworthy, even if the principal

[1] Compare Prendergast (1999) for an overview.

finds that the agent wrongly rejected a project he cannot undue the agent's decision.[2] The probability of costly double-checking rejected projects is precisely the decision variable at the principal's hand which is contractually arranged. The way this contract-contingent variable influences the choice of effort is market-driven as the agent anticipates the additional information that the market receives through double-checking. Offering a non-negative bonus for successfully implemented projects, represents the explicit incentive. Assuming investigating the projects by the agent is optimal, we find in presence of both incentives that only one is used, namely the incentive which grants the higher benefit-to-cost ratio. The higher the prior probability of an implemented project to be successful the more likely is the optimal use of the hybrid incentive instead of triggering the explicit incentive. The intuition behind this result is found firstly in a decrease of expected double-checking cost as only charged for rejected projects. Secondly, expected cost of a bonus does increase as these have to be paid whenever an implemented project performs well.

One defining assumption underlying the chain of arguments with respect to the hybrid incentive is credibility of the principal. If she announces a double-checking rate, then this affects the agent's effort decision if and only if the agent takes her announcement to be trustworthy. This issue is further discussed in section 3.4.

Our model is embedded in the branch of the career concern literature which treats the information of an acting agent to be endogenous[3], which originates in Milbourn et al. (2001). They model an agent who might undertake some costly effort to receive a more precise signal. They find an over investment[4] in precision as long as the agent exhibits career concerns. The reason is

[2]It could be argued that the market environment has changed and thus the time to implement has already passed once the principal double-checks.

[3]Usually precision is taken exogenously and effort adds on the output on average, compare Holmström (1982/99).

[4]The costs are borne by the firm in their model, instead of being carried by the agent.

found in a combination of two crucial assumptions. Firstly, the probability of being smart is assumed to equal the chance of a good project. Secondly, only implemented projects allow for inference with respect to type. Rejecting a project prevents any updating informational-wise as no new information is generated. Put in other words, the agent does not face any risk to prove himself, which can go either way. For this reason the option to reject is called a safe haven. An increased precision prevents from executing bad projects and consequently influences the inference process by the market in the agent's favor.

Suurmond et al. (2004) investigate the adverse selection issue involved once the agent is aware of his type. They find that the agent knowing his type might be welfare enhancing as the smart agent puts in extra effort to distinguish himself. The dumb agent however, undertakes inefficient actions to mimic the smart type. Which force is superior, depends on the parameters. We focus on the moral hazard issue by assuming no party has knowledge of the agent's type, not even the agent himself. Swank and Visser (2008) analyze the consequences of reputational concerns within a sequential setting in which two agents evaluate a project after another. Only if both agents approve, the project is executed. Within this public project framework, sufficiently strong reputational concerns lead the first agent to free-ride by delegating the evaluation decision to the second agent who then has strong incentives to carefully evaluate the project. More closely related to our model is Bar-Isaac (2012) who uses a project choice model to examine the effect of transparency on the agent incentives to exert effort. An exogenously given risk premium by the market favors either the risky or the conservative project choice. While the latter one does not make use of information, the risky project heavily hinges on the agent's ability to properly process information. Bar-Isaac (2012) finds that transparency boosts the incentive to exert effort as long as the market favors the risky project. The reason is that both the benefit of effort and the risk premium point into the same direction. If these two are not aligned, then transparency decreases the incentives to exert effort.

A monitoring instrument at the principal's hand, like double-checking, which involves an ex ante commitment to evaluate or investigate ex post, has been analyzed already in Khalil and Lawarrée (2001).[5] They model an adverse selection model and introduce multiple variables to be potentially monitored in order to screen the agent's type. They find that it is beneficial to the principal to choose ex post which variables are monitored since dumb agents are not sure which variable to mimic best. Chen et al. (2013) analyze the issue of commitment to monitor within an environmental application between a regulator and a polluting firm. They find that the regulator's commitment to monitor the firm is as efficient as a no-commitment scheme. While the commitment issue is also present in our model, the key difference is the informational asymmetry with respect to the agent's type. We assume that neither the agent himself nor any other party knows his type, compared to both Khalill and Lawarrée (2001) and Chen et al. (2013) who investigate this issue using an adverse selection model. To the best of the author's knowledge, our model is the first which combines career concerns with double-checking in a moral hazard environment.

The rest of the paper is organized as follows: The next section introduces the basic model including the timing of the game. Section 3.3 analyzes the different incentive schemes. Section 3.4 presents a discussion and section 3.5 concludes.

3.2 The Basic Model

A principal delegates the evaluation of a project to an agent. Both are risk neutral. The project outcome η depends on the state of the world μ. Let $\mu \in$

[5]Compare also Baron and Besanko (1984).

$\{G, B\}$ be the two states which can be good or bad. Denote the probability of a good state with $\Pr(\mu = G) = \gamma$. The agent decides about implementation or rejection of the project. The project outcome is $\eta = h > 0$ if the state is good, i.e. $\mu = G$ and negative if executed in a bad state $\eta = -h < 0$[6]. The agent can undertake some costly effort to receive a signal $s \in \{g, b\}$ with $\Pr(s = g) = \gamma$ about the underlying state of the world. In order to receive a relevant signal the agent requires both to be informed and to be smart. The probability of being informed is $\pi(e) \in [0, 1]$ with $\frac{\partial \pi(e)}{\partial e} > 0$ and $\frac{\partial^2 \pi(e)}{(\partial e)^2} < 0$. The more effort e is exerted, the more likely is the agent informed, even though the likelihood increments of being informed are decreasing in e. The cost of effort $c(e) \in [0, \infty)$ with $\frac{\partial c(e)}{\partial e} > 0$ and $\frac{\partial^2 c(e)}{(\partial e)^2} > 0$ bears the agent entirely. The agent is either smart (sm) or dumb (du) with $\Pr(sm) = \alpha \in [0, 1]$ being the probability of being smart. Neither party is aware of the agent's type. For a dumb agent the signal is pure noise independent of the level of effort. For a smart agent the signal is true if he is also informed, and pure noise otherwise. This information process has been introduced by Suurmond et al. (2004) and is summarized by the probability of a state conditionally on a signal: $\Pr(G|g)$ [7] $= \alpha\pi(e) + (1 - \alpha\pi(e))\gamma$. Given a signal indicating a good state G, the precision is perfect for a smart and informed agent. Is he however, either dumb or uninformed, the signal carries only noise and the probability of G equals its prior probability, i.e. γ. The probability of the complementary event is $\Pr(B|g) = (1 - \alpha\pi(e))(1 - \gamma)$. The two other possible conditional probabilities are derived analogously:
$\Pr(B|b) = \alpha\pi(e) + (1 - \alpha\pi(e))(1 - \gamma)$ and $\Pr(G|b) = (1 - \alpha\pi(e))\gamma$.
The risk neutral agent has no endowment[8] and exhibits career concerns.

[6] Symmetry is assumed for simplicity but not necessary, as long as good is positive and bad is negative and h is large enough, such that it is always optimal to offer a contract to the agent.

[7] Expression is an abbreviation of $\Pr(\mu = G|s = g)$. In the sequel, expressions involving probabilities are abbreviated in this manner.

[8] This assumption rules out contingent punishment payments offered by the principal.

The latter are modeled via the posterior beliefs the market has about the agent's type. The degree of these concerns to the agent is represented by a multiplying scalar $\lambda \geq 0$.

The principal is ultimately interested in the expected project outcome. She has two instruments to induce the agent to exert effort. First, she can pay a non-negative bonus w if the project is implemented and turns out good. Second, the principal might investigate some rejected projects with probability β, double-checking the agent's decision. This activity costs $C > 0$ and purely generates the information about the correctness of the rejection decision which then becomes available to the principal, the agent, and the market. We assume that the project is not to be executed once the principal has discovered a project wrongly rejected.[9] In that sense, double-checking is ex post inefficient.[10] Ex ante though, it induces incentives to exert effort for the agent who desires to be perceived as smart. A smart agent is more likely to correctly reject a project. Even though double-checking does not lead to undo a wrong implementation decision, it does however produce the information whether or not the decision of the agent was right. The utility functions of the agent and the principal are given by $U^P(\beta, w) = E[\eta - w] - \beta C$ and $U^A(e) = E[w + \lambda\alpha] - c(e)$. Both utility functions consist of three additively separable components. The principal cares for the expected project outcome η, pays the expected bonus and the cost of the double-checking activity. For the agent, the expected bonus lifts his utility. He bears the cost of effort and exhibits career concerns.

[9]This assumption ensures the focus of our analysis is on the career concerns effects of double-checking.

[10]We assume that the principal prefers to stick to β ex post. This could be due to reputational concerns if she is interacting with many agents. However, we do not model these reputational concerns explicitly. This issue is further discussed in section 3.4.

The timing of the game is as follows:

0	1	2	3	4	5
nature chooses type and state	principal offers contract with β and w	agent accepts contract	agent decides on effort and project	principal double-checks with β if rejected	payments are made and posteriors are updated

In stage 0, nature draws the type of the agent and the state of the world. Both remain unknown to all parties. In stage 1, the principal decides about the level of β and w. Upon accepting the contract in stage 2, the agent optimally chooses effort and receives a signal about the state in stage 3. The signal is potentially used by the agent with respect to his implementation decision. If rejected, the decision is potentially checked in stage 4. If implemented, the project is realized. Posterior beliefs are updated, and payments are made accordingly, in stage 5.

3.3 Main Results

We employ the equilibrium concept of a Perfect Bayesian Nash Equilibrium which consists of three parts. For the agent it states an effort level and a decision rule potentially based on the received signal. Secondly, it determines for the principal both, w and β. The third part requires the market to update its beliefs via Bayesian Updating. Moreover, any choice must be optimal, given the other choices. We solve the game using backward induction. The proposed strategy concerning the implementation is to follow his signal. That is to say, a reception of $s = g$ is followed by choosing to implement and a rejection in case of $s = b$. Denote $\widehat{\alpha}^I_{right}$ the belief of the market that the agent is smart once a correct implementation decision is revealed. Denote $\widehat{\alpha}^I_{wrong}$

the belief of the market that the agent is smart after a wrong implementation decision by the agent. Analogously, denote $\widehat{\alpha}^{R}_{right}$ the belief after a correctly decided rejection and $\widehat{\alpha}^{R}_{wrong}$ otherwise. The following relations hold:

$$\widehat{\alpha}^{I}_{right} = \frac{\pi\left(\widehat{e}\right) + \left(1 - \pi\left(\widehat{e}\right)\right)\gamma}{\alpha\pi\left(\widehat{e}\right) + \left(1 - \alpha\pi\left(\widehat{e}\right)\right)\gamma}\alpha \geq \alpha \geq \frac{\left(1-\gamma\right)\left(1 - \pi\left(\widehat{e}\right)\right)}{\left(1-\gamma\right)\left(1 - \alpha\pi\left(\widehat{e}\right)\right)}\alpha = \widehat{\alpha}^{I}_{wrong} \tag{3.1}$$

and

$$\widehat{\alpha}^{R}_{right} = \frac{\pi\left(\widehat{e}\right) + \left(1 - \pi\left(\widehat{e}\right)\right)\left(1-\gamma\right)}{\alpha\pi\left(\widehat{e}\right) + \left(1 - \alpha\pi\left(\widehat{e}\right)\right)\left(1-\gamma\right)}\alpha \geq \alpha \geq \frac{\left(1 - \pi\left(\widehat{e}\right)\right)\gamma}{\left(1 - \alpha\pi\left(\widehat{e}\right)\right)\gamma}\alpha = \widehat{\alpha}^{R}_{wrong}. \tag{3.2}$$

The notation $\widehat{e}$ indicates the market's belief of the effort choice. Making right decisions is more likely made by smart agents, which is reflected in $\widehat{\alpha}_{right} \geq \alpha$. Vice versa, making wrong decisions hurts the career concerns, i.e. $\alpha \geq \widehat{\alpha}_{wrong}$. Depending on the distribution of the states the highest posterior belief is reached by correctly implementing or correctly rejecting the project. For equally likely states, i.e. $\gamma = \frac{1}{2}$ both posterior beliefs are equal, i.e. $\widehat{\alpha}^{I}_{right} = \widehat{\alpha}^{R}_{right}$. If $\gamma > \frac{1}{2}$, then correctly rejecting is less likely and hence rather made by a smart agent, thus it holds for this range that $\widehat{\alpha}^{R}_{right} > \widehat{\alpha}^{I}_{right}$. The same logic applies for the range $\gamma < \frac{1}{2}$ with correctly implementing being the best posterior, i.e. $\widehat{\alpha}^{I}_{right} > \widehat{\alpha}^{R}_{right}$.[11]

In case the project is rejected and not double-checked, the market's posterior beliefs equal the priors since no relevant information is revealed. We sharpen our focus on equilibria involving a positive optimal effort level, since our intention of the paper is to analyze the consequences of career concerns with respect to the optimal use of different incentives. The agent must sufficiently care about his reputation, since the only harm of implementing a wrong project is on his reputation. If he does not care about his perception, then

[11] Consider the boundary case $\gamma = 0$ ($\gamma = 1$), then the relation still holds, thus $\widehat{\alpha}^{I}_{right} > \widehat{\alpha}^{R}_{right}$ ($\widehat{\alpha}^{R}_{right} > \widehat{\alpha}^{I}_{right}$) even though the agent never implements (rejects) given the strategy to follow his signal.

he should implement irrespective of the received signal due to the explicit incentives. Therefore, the following assumption is introduced:

Assumption 1 *Assume* $\lambda \geq \frac{(1-\alpha\pi(e))^2\gamma(\gamma+(1-\gamma)\alpha\pi(e))}{(\alpha\pi(e))^2(1-\alpha)}w^*$.

The next lemma ensures the optimality of the proposed strategy that the agent's implementation decision is characterized by following his signal.

Lemma 1 *Given Assumption 1 and a positive effort level, then it is always optimal for the agent to follow his signal.*
Proof. *See the Appendix.* ■

Notice, for $w^* = 0$, Assumption 1 is automatically fulfilled. Three cases are considered. The first two cases investigate the effect of pure explicit or hybrid incentives, respectively. The third case analyzes the interaction effect of both kinds of incentives.

3.3.1 Case 1: Explicit incentives

In this case the principal can only choose the optimal w^* in order to incentivize the agent. The bonus is granted if the agent implements a good project. For a given w^* and sticking to the following signal behavior, the agent chooses his unobservable effort level optimally in stage 2. The utility function of the agent is given by:

$$\begin{aligned} U^A(e) &= E[w + \lambda\alpha] - c(e) \quad (3.3) \\ &= \Pr(g)\Pr(G|g)\, w^* + \lambda \Pr(g)\left(\Pr(G|g)\,\widehat{\alpha}^I_{right} + \Pr(B|g)\,\widehat{\alpha}^I_{wrong}\right) \\ &+ \lambda \Pr(b)\,\alpha - c(e) \end{aligned}$$

The first-order condition offsets the marginal benefit of effort with its marginal costs.

$$\frac{\partial U^A(e)}{\partial e} = \gamma(1-\gamma)\alpha\frac{\partial \pi(e)}{\partial e}\left(\lambda\left(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong}\right) + w^*\right) - \frac{\partial c(e)}{\partial e} = 0 \quad (3.4)$$

We assume that the optimal effort level implied by equation (3.4) is positive. The higher the effort, the higher the probability of a correct decision. Correctly implemented projects have two benefits for the agent: the contractually arranged bonus w^* and his increase in reputation $\widehat{\alpha}^I_{right}$. Moreover, a correct rejection prevents the market from forming unfavorable beliefs about the agent, i.e. $\widehat{\alpha}^I_{wrong}$. Reputational concerns and the bonus point in the same direction such that they both enhance the marginal benefit of effort. In fact, applying the implicit function theorem shows $\frac{\partial e}{\partial w} > 0$.[12] In anticipation of the agent's behavior the principal's utility function is given by:

$$\begin{aligned} U^P(w) &= E[\eta - w] \qquad (3.5) \\ &= \Pr(g)\left(\Pr(G|g) - \Pr(B|g)\right)h - \Pr(g)\Pr(G|g)\,w \end{aligned}$$

Increasing the bonus leads not only to higher incentives for the agent, but also to higher costs for the principal. The optimal bonus w^* trades off both effects and is given by:

$$\begin{aligned} w^*_{Case\ 1} = & \frac{2h\gamma(1-\gamma)\alpha\left(\frac{\partial\pi(e)}{\partial e}\right)^2}{\gamma(1-\gamma)\alpha\left(\frac{\partial\pi(e)}{\partial e}\right)^2 - \gamma(\gamma+(1-\gamma)\alpha\pi(e))\frac{\partial^2\pi(e)}{(\partial e)^2}} \qquad (3.6) \\ & + \frac{\gamma(\gamma+(1-\gamma)\alpha\pi(e))\lambda\left(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong}\right)\frac{\partial^2\pi(e)}{(\partial e)^2}}{\gamma(1-\gamma)\alpha\left(\frac{\partial\pi(e)}{\partial e}\right)^2 - \gamma(\gamma+(1-\gamma)\alpha\pi(e))\frac{\partial^2\pi(e)}{(\partial e)^2}} \\ & - \frac{\frac{\gamma+(1-\gamma)\alpha\pi(e)}{(1-\gamma)\alpha}\frac{\partial^2 c(e)}{(\partial e)^2}}{\gamma(1-\gamma)\alpha\left(\frac{\partial\pi(e)}{\partial e}\right)^2 - \gamma(\gamma+(1-\gamma)\alpha\pi(e))\frac{\partial^2\pi(e)}{(\partial e)^2}} \end{aligned}$$

[12] See the Proof of Proposition 1 in the Appendix. It is due to assumptions about concavity of $\pi(e)$ and convexity of $c(e)$.

The optimal level of the bonus increases in the project outcome spread between correctly and wrongly implementing projects, $2h$. The bonus is lower the higher the cost of effort. A bonus aims at inducing effort, hence enlarged cost of effort that has to be compensated by the principal naturally results in a smaller bonus. Interestingly, the optimal bonus is also lower, the higher the agent's career concerns. The intuition behind the negative impact of λ is due to the decreasing benefit of effort captured in the concavity of $\pi(e)$. In the absence of any bonus, the agent has incentives to exert effort in order to influence the market's posterior beliefs about his type in his favor. The bonus incentives are additional to these implicit incentives and less effective the more present the implicit incentives are.

3.3.2 Case 2: Hybrid incentives

What changes if the principal can only choose the probability of double-checking β instead of a bonus w? The utility function of the agent changes accordingly:

$$\begin{aligned} U^A(e) &= \lambda E[\alpha] - c(e) \qquad (3.7) \\ &= \lambda \Pr(g)\left(\Pr(G|g)\,\widehat{\alpha}^I_{right} + \Pr(B|g)\,\widehat{\alpha}^I_{wrong}\right) \\ &\quad + \lambda \Pr(b)\left(\beta^*\left(\Pr(G|b)\,\widehat{\alpha}^R_{wrong} + \Pr(B|b)\,\widehat{\alpha}^R_{right}\right) + (1-\beta^*)\,\alpha\right) - c(e) \end{aligned}$$

The career concerns play a larger role due to the potential double-checking activity by the principal. The agent interprets this activity as an enhanced opportunity to show his abilities. Taking the announced probability of double-checking β^* as given and trustworthy, the agent anticipates the modified consequences of rejecting a project, compared to case 1. Any rejected project is checked with probability β^* and then reveals perfectly the correctness of the agent's decision. The following first-order condition adjusts for the changed environment and considers the effect of double-checking:

$$\frac{\partial U^A(e)}{\partial e} = \gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\lambda\left(\left(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong}\right) + \beta^*\left(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong}\right)\right) - \frac{\partial c(e)}{\partial e} \tag{3.8}$$

The probability of double-checking β^* boosts the incentives to exert effort, i.e. $\frac{\partial e}{\partial \beta^*} > 0$.[13] In particular, if any rejected project is about to be checked then the reputational concerns are twice as pronounced as in the absence of any check for equally likely states. This is seen by comparing the terms with $\beta^* = 0$ and $\beta^* = 1$ for $\gamma = \frac{1}{2}$. Yet again, double-checking binds the principal's resources and comes at a cost C per executed check. The utility of the principal changes to:

$$\begin{aligned} U^P(\beta) &= E[\eta] - \beta C \\ &= \Pr(g)\left(\Pr(G|g) - \Pr(B|g)\right)h - \beta C \end{aligned} \tag{3.9}$$

The principal optimally chooses β at the beginning of the game. It is assumed that this announcement is credible. The principal maximizes his utility by choosing:

$$\beta^*_{Case\ 2} = \frac{2h\lambda\left(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong}\right)\left(\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\right)^2 - C\frac{\partial^2 c(e)}{(\partial e)^2}}{-\lambda\gamma(1-\gamma)\left(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong}\right)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}C} - \frac{\left(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong}\right)}{\left(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong}\right)} \tag{3.10}$$

As for the optimal level of the bonus, the spread in project outcome $2h$ has positive effects on the optimal probability to double-check. Moreover, also the cost of effort points in the same direction, namely a negative effect. For

[13] See the appendix.

the consequence of the degree of exhibited career concerns of the agent, however, the story is quite different. The larger λ, the higher the optimal level β^*. Double-checking rejected projects generates the information whether or not the agent's decision was right. The higher the probability of double-checking, the higher the probability for the market to have access to more information which boosts the implicit incentives to exert effort. Consequently, an increased level of double-checking is made more efficient by an increased level of λ. Nevertheless, the decreasing benefits of effort are also present with the same harmful manner as for the optimal bonus, i.e. the more concave $\pi(e)$, the higher the cost of double-checking.

3.3.3 Case 3: Combination of both incentives

The third case considers a combination of the first two cases. The principal can choose both, a bonus and a double-checking rate. The proposed strategy of the agent remains unchanged. Due to the property of additively separation the agent's utility adds up straightforwardly to:

$$\begin{aligned} U^A(e) &= E[w + \lambda\alpha] - c(e) \\ &= \Pr(g)\Pr(G|g)\,w^* + \lambda\Pr(g)\left(\Pr(G|g)\,\widehat{\alpha}^I_{right} + \Pr(B|g)\,\widehat{\alpha}^I_{wrong}\right) \\ &\quad + \lambda\Pr(b)\left(\beta^*\left(\Pr(G|b)\,\widehat{\alpha}^R_{wrong} + \Pr(B|b)\,\widehat{\alpha}^R_{right}\right) + (1-\beta^*)\,\alpha\right) - c(e) \end{aligned} \tag{3.11}$$

The agent maximizes his utility over e such that the following first derivative results:

$$\begin{aligned} \frac{\partial U^A(e)}{\partial e} &= \gamma(1-\gamma)\,\alpha\frac{\partial\pi(e)}{\partial e}\lambda\left(\left(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong}\right) + \beta^*\left(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong}\right)\right) \\ &\quad + \gamma(1-\gamma)\,\alpha\frac{\partial\pi(e)}{\partial e}w^* - \frac{\partial c(e)}{\partial e} \end{aligned} \tag{3.12}$$

The benefits of effort in bonus and double-checking are linear such that the combined benefit equals the sum. The principal chooses w and β such that her utility function is maximized:

$$\begin{aligned} U^P(\beta, w) &= E[\eta - w] - \beta C \qquad (3.13) \\ &= \Pr(g)(\Pr(G|g) - \Pr(B|g))h - \Pr(g)\Pr(G|g)w - \beta C \end{aligned}$$

The following proposition describes the equilibrium solving this optimization problem.

Proposition 1 *Given Assumption 1, a case distinction with respect to* λ *is made. Suppose* $\lambda \in [\frac{(1-\alpha\pi(e))^2\gamma(\gamma+(1-\gamma)\alpha\pi(e))}{(\alpha\pi(e))^2(1-\alpha)} w^*_{Case\ 1}; \frac{C}{\gamma(\gamma+(1-\gamma)\alpha\pi)\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)})$*, then* e^* *is implied by setting equation (3.12) to zero. The agent follows his signal. The principal choices are* $w^*{=}w^*_{Case\ 1}$ *and* $\beta^* = 0$.
Suppose $\lambda \in [\frac{C}{\gamma(\gamma+(1-\gamma)\alpha\pi)\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)}; \infty)$*, then the agent chooses* e^* *such that equation (3.12) set to zero is fulfilled. The agent follows his signal. The principal chooses* $w^*{=}0$ *and* $\beta^* = \beta^*_{Case\ 2}$*. In both instances the market updates its beliefs via Bayesian updating using the corresponding optimal effort level.*
Proof. *See the Appendix.* ■

The degree of career consciousness of the agent characterizes the equilibrium of this model. It turns out that only one incentive instrument is used. Intuitively, both incentives target at inducing the agent to exert effort. Since there is no spill-over effect present, i.e. using one incentive does not result in a more efficient use of the other incentive, choosing the incentive which has a higher benefit-to-cost of effort ratio is optimal. The inequality $\lambda\left(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong}\right) \gtrless \frac{C}{\gamma(\gamma+(1-\gamma)\alpha\pi)}$ drives the result. Optimality requires a superior ratio which hinges on the fact how effectively w or β induce the agent to exert unobservable effort. In particular, the principal prefers using explicit incentives if either an execution of a double-check is too costly or if the effect of making a right implementation decision is not sufficiently strong for the agent. The latter happens if the degree of career concerns is not strongly valued or in case of a narrow spread between posterior beliefs. Most interestingly, double-checking is favored by an increase in the prior probability of good states γ. The reasoning is found in the increased probability of correctly implemented projects which results in both lower expected costs of β, since it only takes place for rejected projects with a certain probability, and higher expected cost of w. By the same line of argument, the principal rather makes use of the implicit incentive if the prior probability of the agent being smart is higher.

For a sufficiently low value of λ, i.e. in case of failing Assumption 1, the agent has no incentive to exert effort and follow his signal but to implement in any case. Since exerting effort supports the implementation decision, there is no benefit of effort but only costs in case of this implementation decision rule. This is optimal for the agent, as the only drawback of implementing wrong projects is being perceived as not so smart.

3.4 Discussion

The agent chooses her effort level optimally in anticipation of a specific bonus and a certain probability of rejected projects to be checked. For this mechanism to work, the principal's credibility to act in accordance with her offered contract to the agent is of crucial importance. Per se the principal has no interest in paying the bonus or costly checking projects after the agent has already done his job. Even though the instrument is inefficient ex post from the principal's point of view, we showed that she does not set both to zero due to the ex ante incentives for the agent to induce effort. If the agent however, doubts the principal's credibility to act accordingly, these ex ante incentives vanish since for him double-ckecking is efficient ex post. In case of explicit incentives, the assumption is met by a sufficiently high penalty cost for deviating. If the principal hesitates to pay, the agent credibly threatens to file a lawsuit. For the announcement of the double-ckecking rate β the issue is more complicated, since the agent's interest in executing the check ex post is less clear compared to the case of the bonus. For this reason, we consider that the principal exhibits reputational concerns which ensures that her ex ante announcement appears to be credible to her employees. The threat of losing her reputation once, and hence losing this kind of incentive makes her act in accordance with her announcement.

So far a bonus was paid for successfully implemented projects only. What if the bonus is made contingent on a correct decision by the agent? That is to say, the agent claims a bonus for correctly rejecting in addition to correctly implementing. This modification leads to increased incentives to exert effort for the agent. As not only the information about the correctness of the evaluation decision is generated but also rewarded if correct. For the same reason this bonus leads to increased cost of executed double-checks. Qualitatively speaking, the results of Proposition 1 still hold.

In Milbourn et al. (2001) the assumption of a safe haven was crucial for career concerns to induce incentives. Per se, rejecting a project does not reveal the correctness of the implementation decision and offers the agent a safe haven such that he does not face the risk of proving himself. In our model the safe haven plays also an important role but for quite different reasons. Milbourn et al. (2001) model the type space as the conditional probability of a project to be successful. When the market has access to the entire range of events and is able to infer for any instance the agent's type then the agent can not shift the probabilities about his type in his favor as exerting effort only increases the precision of a signal but leaves the prior probability of good projects unchanged. Consequently, the presence of reputational concerns has no influence on the agents optimal effort choice, in absence of a safe haven. In our model instead, the safe haven is important for the hybrid incentive to work. Double-checking is obsolete when each project, irrespective of the evaluation decision, generates the information whether or not the agent did the right choice. The agents desire to be perceived favorably with respect to her type is nevertheless present even if there is no safe haven, which can be seen by a positive optimal effort for $w = 0$ and $\beta = 1$.

3.5 Conclusion

Within a project choice model we introduce a hybrid incentive which is at the same time contract-contingent and market-driven. This hybrid incentive works best to induce a career-conscious agent to exert effort when the likelihood of having a project successfully implemented is quite high even without further investigation by the agent. This allows for a more nuanced view on optimal labor contracts for experts. Future research should investigate the optimal use of hybrid incentives in the long-run akin Gibbons and Murphy analysis about the interplay between explicit and implicit incentives. Stressing the driving inequality causing the distinction which instrument is used, an established reputation decreases both marginal benefit-to-cost of effort ratios such that a prediction ought to be an object of future research.

3.6 Appendix

3.6.1 Proof of lemma 1

The agent follows his signal if and only if two inequalities hold. For $s = g$, the utility of implementation must be larger or equal to the utility of rejection, i.e. $\Pr(G|g)\, w^* + \lambda\alpha - c(e^*) \geq \beta^*\lambda(\Pr(G|g)\, \widehat{\alpha}^R_{wrong} + \Pr(B|g)\, \widehat{\alpha}^R_{right}) + (1-\beta^*)\, \lambda\alpha - c(e^*)$. Notice, the expectation of the agent's type equals the prior probability α in equilibrium. As the agent himself is also not aware of his type, he can not cheat on this, in equilibrium. Simplifying the inequality to $\Pr(G|g)\, w^* \geq \beta^* \lambda \left(\Pr(G|g)\, \widehat{\alpha}^R_{wrong} + \Pr(B|g)\, \widehat{\alpha}^R_{right} - \alpha\right)$ shows that it is always fulfilled. The left-hand side (LHS) is non-negative and the right-hand side (RHS) is negative. The second inequality aims at $s = b$. Then the utility of rejecting must be larger or equal to the utility of implementing, i.e. $\lambda\beta^* \left(\Pr(G|b)\, \widehat{\alpha}^R_{wrong} + \Pr(B|b)\, \widehat{\alpha}^R_{right}\right) + (1-\beta^*)\, \lambda\alpha - c(e^*) > \Pr(G|b)\, w^* + \lambda \left(\Pr(B|b)\, \widehat{\alpha}^I_{wrong} + \Pr(G|b)\, \widehat{\alpha}^I_{right}\right) - c(e^*)$ which simplifies to $\lambda(\alpha - \Pr(B|b)\, \widehat{\alpha}^I_{wrong} - \Pr(G|b)\, \widehat{\alpha}^I_{right}) > \Pr(G|b)\, w^*$. The LHS is non-negative as $\left(\alpha - \Pr(B|b)\, \widehat{\alpha}^I_{wrong} - \Pr(G|b)\, \widehat{\alpha}^I_{right}\right) = \frac{\alpha\pi(\widehat{e})}{\gamma+(1-\gamma)\alpha\pi(\widehat{e})} \frac{(1-\alpha)\alpha\pi(\widehat{e})}{(1-\pi(\widehat{e})\alpha)}$. Since the RHS is non-negative as well, however, a sufficiently large λ must be assumed, since a project might go well even in presence of a conflicting signal, the agent has an incentive to deviate from the strategy and implement anyways as long as he does not care sufficiently enough for his reputation. If $\lambda \geq \frac{\Pr(G|b)}{\left(\alpha - \Pr(B|b)\widehat{\alpha}^I_{wrong} - \Pr(G|b)\widehat{\alpha}^I_{right}\right)} w^*$ then the second inequality holds which is exactly as Assumption 1 requires. Consequently, Assumption 1 i.e. $\lambda \geq \frac{(1-\alpha\pi(e))^2\gamma(\gamma+(1-\gamma)\alpha\pi(e))}{(\alpha\pi(e))^2(1-\alpha)} w^*$, ensures optimality of the following-signal strategy. **q.e.d.**

3.6.2 Proof of Proposition 1

Case 1

Inserting the probabilities into (3.3) gives
$U^A(e) = \gamma\left(\alpha\pi(e) + (1-\alpha\pi(e))\,\gamma\right) w^*$
$+\lambda\gamma((\alpha\pi(e) + (1-\alpha\pi(e))\,\gamma)\widehat{\alpha}^I_{right} + (1-\alpha\pi(e))\,(1-\gamma)\,\widehat{\alpha}^I_{wrong}) + \lambda(1-\gamma)\,\alpha$
$-c(e)$. Taking the first derivative with respect to effort results in $\frac{\partial U^A(e)}{\partial e} = \gamma\alpha\frac{\partial\pi(e)}{\partial e}(1-\gamma)\, w^* + \lambda\gamma(1-\gamma)\,\alpha\frac{\partial\pi(e)}{\partial e}(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong}) - \frac{\partial c(e)}{\partial e}$ which is equivalent to (3.4). Using implicit function theorem, i.e. $\frac{\partial e}{\partial w^*} = -\frac{\frac{\partial U^A(e)}{\partial e}\big/\partial w^*}{\frac{\partial U^A(e)}{\partial e}\big/\partial e}$, to analyze the effect of in increase in w^* on effort:

$\frac{\partial e}{\partial w^*} = -\frac{\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}}{\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\lambda\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+w^*\right)-\frac{\partial^2 c(e)}{(\partial e)^2}} > 0$. Expression is positive due to the assumptions $\frac{\partial\pi(e)}{\partial e} > 0$; $\frac{\partial^2\pi(e)}{(\partial e)^2} < 0$ and $\frac{\partial^2 c(e)}{(\partial e)^2} > 0$. The principal anticipates the positive effect of a bonus on effort. She maximizes her utility over w. (3.5) leads to $U^P(w) = \gamma\left(\alpha\pi(e) + (1-\alpha\pi(e))\gamma - (1-\alpha\pi(e))(1-\gamma)\right)h - \gamma\left(\alpha\pi(e) + (1-\alpha\pi(e))\gamma\right)w$ after inserting the probabilities. Taking the first derivative with respect to w results in $\frac{\partial U^P(w)}{\partial w} = \gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial w}(2h-w) - \gamma\left(\alpha\pi(e) + (1-\alpha\pi(e))\gamma\right)$. Using chain rule, i.e. $\frac{\partial\pi(e)}{\partial w} = \frac{\partial\pi(e)}{\partial e}\frac{\partial e}{\partial w}$ and setting it to zero, leads to: $-\frac{\left(\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\right)^2}{\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\lambda\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+w^*\right)-\frac{\partial^2 c(e)}{(\partial e)^2}}(2h-w^*) - \gamma\left(\alpha\pi(e) + (1-\alpha\pi(e))\gamma\right) = 0$ which is solved by 3.6.

Case 2

Inserting the probabilities into (3.7) gives
$U^A(e) = \lambda(\gamma((\alpha\pi(e) + (1-\alpha\pi(e))\gamma)\widehat{\alpha}^I_{right} + (1-\alpha\pi(e))\ \ (1-\gamma)\widehat{\alpha}^I_{wrong}) + (1-\gamma)(\beta^*(((1-\alpha\pi(e))\gamma)\widehat{\alpha}^R_{wrong} + (\alpha\pi(e) + (1-\alpha\pi(e))(1-\gamma))\widehat{\alpha}^R_{right}) + (1-\beta^*)\alpha)) - c(e)$. The first derivative with respect to e results in $\frac{\partial U^A(e)}{\partial e} = \lambda(\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong}) + (1-\gamma)\beta^*\gamma\alpha\frac{\partial\pi(e)}{\partial e}(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong})) - \frac{\partial c(e)}{\partial e}$ which is equivalent to (3.8). Using implicit function theorem to analyze the effect of in increase in β^* on the effort level:

$$\frac{\partial e}{\partial\beta^*} = -\frac{\frac{\partial\frac{\partial U^A(e)}{\partial e}}{\partial\beta^*}}{\frac{\partial\frac{\partial U^A(e)}{\partial e}}{\partial e}} = -\frac{\lambda\gamma(1-\gamma)\alpha\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\frac{\partial\pi(e)}{\partial e}}{\lambda\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)-\frac{\partial^2 c(e)}{(\partial e)^2}} > 0$$

The utility of the principal, compare equation (3.9), is given by:
$U^P(\beta) = \gamma\left(\alpha\pi(e) + (1-\alpha\pi(e))\gamma - (1-\alpha\pi(e))(1-\gamma)\right)h - \beta C$. Taking the first derivative gives: $\frac{\partial U^P(\beta)}{\partial\beta} = 2h\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial\beta} - C$. Using chain rule, so $\frac{\partial\pi(e)}{\partial\beta} = \frac{\partial\pi(e)}{\partial e}\frac{\partial e}{\partial\beta}$ and setting it to zero, leads to:
$-\frac{2h\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\left(\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\right)^2}{\lambda\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)-\frac{\partial^2 c(e)}{(\partial e)^2}} - C = 0$ which is solved by expression (3.10).

Case 3

Considering equation (3.11), the utility of the agent changes to
$U^A(e) = \gamma(\alpha\pi(e) + (1-\alpha\pi(e))\gamma) w^* + \lambda\gamma((\alpha\pi(e) + (1-\alpha\pi(e))\gamma)\widehat{\alpha}^I_{right} + (1-\alpha\pi(e))(1-\gamma)\widehat{\alpha}^I_{wrong})$
$+\lambda(1-\gamma)(\beta^*((1-\alpha\pi(e))\gamma\widehat{\alpha}^R_{wrong} + (\alpha\pi(e) + (1-\alpha\pi(e))(1-\gamma))\widehat{\alpha}^R_{right}) + (1-\beta^*)\alpha) - c(e)$. Taking the first derivative with respect to effort gives $\frac{\partial U^A(e)}{\partial e} = \gamma\alpha\frac{\partial\pi(e)}{\partial e}(1-\gamma)w^* + \lambda\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}(\widehat{\alpha}^I_{right} - \widehat{\alpha}^I_{wrong})$
$+\lambda(1-\gamma)\beta^*\gamma\alpha\frac{\partial\pi(e)}{\partial e}(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong}) - \frac{\partial c(e)}{\partial e}$ which is equivalent to equation 3.12. Applying the implicit function theorem allows for:

$$\frac{\partial e}{\partial w} = -\frac{\frac{\partial\frac{\partial U^A(e)}{\partial e}}{\partial w}}{\frac{\partial\frac{\partial U^A(e)}{\partial e}}{\partial e}} = -\frac{\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}}{\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\lambda\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)+w^*\right)-\frac{\partial^2 c(e)}{(\partial e)^2}}$$

$$\frac{\partial e}{\partial \beta} = -\frac{\frac{\partial\frac{\partial U^A(e)}{\partial e}}{\partial \beta}}{\frac{\partial\frac{\partial U^A(e)}{\partial e}}{\partial e}} = -\frac{\lambda\gamma(1-\gamma)\alpha\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\frac{\partial\pi(e)}{\partial e}}{\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\lambda\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)+w^*\right)-\frac{\partial^2 c(e)}{(\partial e)^2}}$$

Inserting probabilities into 3.13 leads to principal's utility:
$U^P(\beta, w) = \gamma(\alpha\pi(e) + (1-\alpha\pi(e))\gamma - (1-\alpha\pi(e))(1-\gamma))h$
$-\gamma(\alpha\pi(e) + (1-\alpha\pi(e))\gamma)w - \beta C$. Recognizing the character of the utility of the principal reduces the first derivatives with respect to w and β, respectively, as follows: $\frac{\partial U^P(\beta,w)}{\partial w} = \frac{\partial U^P(w)}{\partial w}$ and $\frac{\partial U^P(\beta,w)}{\partial \beta} = \frac{\partial U^P(\beta)}{\partial \beta} - \gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial\beta}w$.
Applying chain rule, the latter translates to

$$\frac{\partial U^P(\beta,w)}{\partial \beta} = -\frac{(2h-w)\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\left(\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\right)^2}{\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\lambda\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)+w^*\right)-\frac{\partial^2 c(e)}{(\partial e)^2}} - C.$$

Optimization Problem

The principal optimizes her utility taking the optimizing behavior of the agent into account. She considers the non-negativity constraints of β and w. Any solution is required to fulfill the following Kuhn-Tucker conditions (KTCs): The bonus w must fulfill: $\frac{\partial U^P(\beta,w)}{\partial w} \leq 0$; $w \geq 0$; $w\frac{\partial U^P(\beta,w)}{\partial w} = 0$ and the double-checking rate β: $\frac{\partial U^P(\beta,w)}{\partial \beta} \leq 0$; $\beta \geq 0$; $\beta\frac{\partial U^P(\beta,w)}{\partial \beta} = 0$.
Check first instance Suppose $w > 0$, then $\frac{\partial U^P(\beta,w)}{\partial w} = 0$

$$\Leftrightarrow -\frac{(2h-w)\left(\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\right)^2}{\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\lambda\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)+w^*\right)-\frac{\partial^2 c(e)}{(\partial e)^2}}$$

$$-\gamma\left(\alpha\pi+(1-\alpha\pi)\gamma\right)=0$$

with solution:

$$w^1=\frac{2h-\frac{1}{\left((1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\right)^2\gamma}\left(\frac{\partial^2 c(e)}{(\partial e)^2}-\lambda\gamma\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)(1-\gamma)\right)(\alpha\pi(e)+\gamma(1-\alpha\pi(e)))}{-\frac{1}{\left(\frac{\partial\pi(e)}{\partial e}\right)^2}\frac{\frac{\partial^2\pi(e)}{(\partial e)^2}}{\alpha(1-\gamma)}(\alpha\pi(e)+\gamma(1-\alpha\pi(e)))+1}.$$

Inserted in $\frac{\partial U^P(\beta,w)}{\partial\beta}$ results in

$\frac{\partial U^P\left(\beta,w^1\right)}{\partial\beta}=\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\gamma\left(\alpha\pi\left(e\right)+\left(1-\alpha\pi\left(e\right)\right)\gamma\right)-C$. If negative, then KTCs require $\beta=0$. If positive, then KTCs are violated.

Check second instance Suppose $\beta>0$, then $\frac{\partial U^P(\beta,w)}{\partial\beta}=0$

$$\Leftrightarrow -\frac{(2h-w)\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\left(\gamma(1-\gamma)\alpha\frac{\partial\pi(e)}{\partial e}\right)^2}{\gamma(1-\gamma)\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}\left(\lambda\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\beta^*\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\right)+w^*\right)-\frac{\partial^2 c(e)}{(\partial e)^2}}-C=0$$

with solution

$$\beta^1=-\frac{\left(\left(\widehat{\alpha}^I_{right}-\widehat{\alpha}^I_{wrong}\right)+\frac{1}{\lambda}\left(w-\frac{1}{\gamma\alpha\frac{\partial^2\pi(e)}{(\partial e)^2}}\frac{\frac{\partial^2 c(e)}{(\partial e)^2}+\frac{\left(\frac{\partial\pi(e)}{\partial e}\right)^2}{C}\alpha^2\lambda\gamma^2\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)(1-\gamma)^2(-2h+w)}{1-\gamma}\right)\right)}{\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)}$$

Inserting in $\frac{\partial U^P(\beta,w)}{\partial w}$ gives $\frac{\partial U^P(\beta,w)}{\partial w}=\frac{C-\gamma\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)(\alpha\pi(e)+\gamma(1-\alpha\pi(e)))}{\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)}$. If negative, then KTCs require $w=0$. If positive, then KTCs are violated.

Summary Line of argument in both instances are based on the same inequality:

a.) If $\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)<\frac{C}{\gamma(\gamma+(1-\gamma)\alpha\pi)}$, then $w^*=w^*_{case\ 1}$ and $\beta^*=0$

b.) If $\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)>\frac{C}{\gamma(\gamma+(1-\gamma)\alpha\pi)}$, then $w^*=0$ and $\beta^*=\beta^*_{Case\ 2}$.

c.) If $\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)=\frac{C}{\gamma(\gamma+(1-\gamma)\alpha\pi)}$, then $\frac{\partial U^P}{\partial\beta}=\lambda\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\frac{\partial U^P}{\partial w}$, implying that both are substitutes.

Equilibrium

The equilbrium of this game is fully described by:

For $\lambda\in[\frac{(1-\alpha\pi(e))^2\gamma(\gamma+(1-\gamma)\alpha\pi(e))}{(\alpha\pi(e))^2(1-\alpha)}w^*;\frac{C}{\left(\widehat{\alpha}^R_{right}-\widehat{\alpha}^R_{wrong}\right)\gamma(\gamma+(1-\gamma)\alpha\pi)})$, then e^* is the solution to 3.4 and $w^*=w^*_{case\ 1}$ and $\beta^*=0$ and all posteriors use the corresponding optimal effort level.

For $\lambda \in [\frac{C}{(\widehat{\alpha}^R_{right} - \widehat{\alpha}^R_{wrong})\gamma(\gamma+(1-\gamma)\alpha\pi)}; \infty)$, then e^* is the solution to equation 3.8 set to zero. The principal chooses $w^* = 0$ and $\beta^* = \beta^*_{Case\ 2}$ and all posteriors use the corresponding optimal effort level. **q.e.d.**
Depending on the parameters, the first distinction might not be existent.

3.7 References

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Selbstständigkeitserklärung

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