Reputational Concerns in a Competitive Signalling Model of Innovation Implementation

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Abstract

Existing models of motivational antecedents of individual innovative behaviour typically assume efficient behaviour of workers. This paper contributes by discussing how reputational concerns incentivize signalling behaviour in innovation implementation. By constructing an exploratory model of signalling, testable hypotheses are derived. The proposed model predicts efficient behaviour from all actors in the absence of reputational concerns; a symmetric Nash equilibrium in pure strategies. When reputational concerns are introduced, additional equilibria arise. If only the least creative workers are able to signal, workers may decide to engage in signalling behaviour, given that gains from reputation are sufficiently large. In the extended innovation model, highly creative workers may also decide to signal. Three symmetric equilibria in pure strategies may occur; both workers refrain from signalling for any creative ability level, workers engage in signalling only when attributed with high creative ability, or workers signal no matter their creative ability. Each equilibrium outcome arises for multiple sets of parameter values. Future research must test the empirical validity of these findings.

Keywords: innovation, reputational concerns, signalling, reputational gains

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1 Introduction

Working at a greenhouse for over eight years, ideas on (process) innovations are bound to arise. I like to believe some of my suggestions had cost-saving potential, though my supervisor did not have the same faith in my innovative efforts. Every once in a while, I would attempt to convince my supervisor of their potential for two reasons; firstly, some of these innovations would make my life easier at work. Secondly, I was ready to step up the career ladder and be promoted to a leadership position. Assuming that a reputation for innovation would increase my odds of promotion, I kept trying. Regardless of idle efforts in the past, anticipating reputation gains and a promotion provided the right incentives for me to engage in innovative behaviour.[1]

Schumpeter (1942) has been the first of many to value the importance of innovation. Schumpeter (1942) formulated the process of creative destruction: an on-going process of innovation, in which new products or techniques destroy their predecessors. The firms that do not engage in innovation will therefore be outclassed and replaced by more innovative organisations. In the modern era of continuously evolving market demands and market structures, innovation is key to organisational survival (Baregheh, Rowley & Sambrook, 2009). Past research has mostly assumed innovation to be some function of the individual's creativity, derived mainly from personality traits, and the institutional setting. The literature describes contributing factors for innovation, attempting to define the optimal environment for innovation. The relevance of this type of research is non-deniable. However, to date, we have a limited understanding of the motivational antecedents of employees' innovative behaviour, because traditional research underemphasizes the importance of micro-processes in the innovational process. Most research takes the efficiency-oriented perspective and assumes that in all cases, the most profitable idea will graduate into a settled innovation. As early as in 1981, Kimberly & Evanisko question this view:

'Can it be that the quality of an innovation - as difficult as "quality" may be to determine - does not significantly influence adoption decisions?' (p. 710)

The optimal implementation strategy, choosing the highest quality idea, may be disturbed by processes inherent to the organisational and social framework. This new field of research takes a socio-political view. An employees is faced with a number of differential incentives when deciding on informing the environment of his idea; the incentives that stem from organisational survival may not be dominant. Recently, research has chimed in on this topic, although a comprehensive model of this individual – and social process of idea selection and implementation has not yet been developed.

This research will focus on employee motivations to engage in individual innovative behaviour. A model is developed to incorporate a single individual/social process: reputation. Reputation is a powerful thing; some people may derive their self-worth from it, or your next promotion may be based on your reputation on the work floor. Suurmond, Swank & Visser (2004) describe how reputational concerns cause an agent to worry about how his actions influence his supervisor's perception of him. Such concerns may lead to unnecessary risk aversion; exaggeration of effort and conservatism (Holmström, 1999; Prendergast & Stole, 1996). Potential reputation gains thus have behavioural consequences. This aim of this paper is to model how individual innovative behaviour is affected by reputational concerns. The model of motivational antecedents of individual innovation will provide testable hypotheses for future research, ultimately fitting into the bigger picture of organisational innovation. Before trying to capture the immense process of organisational innovation, it should be clear what is going on at its base: individual innovative behaviour. The current model is subject to too many limitations to provide solid and sound practical implications for organisations now, but future research may improve upon this. This research contributes to the issue: how can organisations invest in the most rewarding innovations? Ultimately, the development of an

[1] After 4,5 years of trying, eventually, I got the promotion!

organisational strategy that is optimal in terms of selection of ideas, and successful in circumvention of defects in the decision process, would have major benefits for organisational performance and overall welfare.

The model is concentrated within a small framework of two workers, competing for idea implementation, and a single supervisor. The workers can increase their chances of implementation by manipulating their signal. The supervisor decides on implementation. The players are only aware of their own creative ability. They derive utility from project payoff, determined by creativity of the idea and reputational gains; effort brings about negative utility. Results show that in the absence of reputational concerns, the model predicts Pareto-efficiency; neither worker exerts effort to signal and the supervisor implements the (one of the) most rewarding idea(s). When reputational concerns are introduced into the restricted model, an additional symmetric equilibrium is established, in which both workers engage in signalling behaviour. This equilibrium requires high benefits to reputation and high odds of signalling success. In the extended model, the latter equilibrium no longer holds. Instead, two other symmetric equilibria in pure strategies arise, in addition to the initial equilibrium of neither worker signalling. One of the equilibria describes workers signalling only when attributed high creative ability. In the other equilibrium, workers signal regardless of their creative ability. From these results, it becomes clear that workers may decide to engage in adverse behaviour of implementation manipulation if the gains of reputation are sufficiently large.

This research paper proceeds as follows. Section 2 provides an extensive literature review on innovation, the role of creativity and the actors involved in the innovation process, the stages of innovation and ultimately, the notion of reputation in innovation. Section 3 introduces the model of reputational concerns in innovation implementation and provides the analysis. Section 4 concludes and presents a discussion of the findings.

2 Literature

To give a comprehensive overview of the relevant literature, what follows is a rather extensive literature review. Starting from the range of definitions of innovation and its relevance, I will move to a discussion of the roles of the different actors in the innovation process. The final section will focus on how the literature has structured the innovation process and ultimately zoom in on the decision process.

2.1 An introduction to innovation

Ever since Schumpeter's (1942) theory on how creative destruction signals a need for organisational change, innovations, researchers have tried to capture many, if not all, aspects of innovation in a concise definition. These definitions thus vary in complexity and comprehensiveness. One of the early, simpler definitions comes from Thompson (1965): "Innovation is the generation, acceptance and implementation of new ideas, processes products or services". (p. 5) Thompson's definition covers stages and types of innovations. Van de Ven (1986) adds to this definition by specifying and emphasizing the four relevant factors: new ideas, people, transactions, and institutional context. Damanpour (1996) describes how innovation can be 'a pre-emptive action' to impact the environment or a response to a change in the environment, again emphasizing the importance of context. Van der Meer (1996) takes a very inclusive approach, describing innovation as all activities that lead to the introduction of something new.

This research fits into the bigger picture of one institutional order: the organisational framework. As defined by Amabile (1983), organisational innovation is 'the successful implementation of creative ideas within an organisation'. Baregheh, Rowley & Sambrook (2009)

researched very many existing definitions of organisational innovation and propose a more comprehensive definition[2]:

"Innovation is the multi-stage process whereby organisations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace." (p. 1334)

This definition is designed around the framework of business organisations. The authors acknowledge the different stages, the different types of innovation and, most importantly, its purpose. Although this is a comprehensive and accurate definition of organisational innovation, it ignores the role of the individual within the organisation. One aspect of organisational innovation remains underemphasized: employees' engagement in the innovative process is of crucial importance. Individual innovative behaviour is described by Bammens (2015) as all activities that involve the generation, promotion and realization of ideas. These ideas may lead to new technologies, products, processes or techniques.

Why would firms engage in this risky activity called innovation? Creative destruction by Schumpeter (1942) predicts that firms that fail to engage in innovation are outclassed and made abundant by their innovative competitors. Innovation is a prerequisite for creating, sustaining and strengthening competitive advantage (Amabile, 1988). Organisational survival is on the line. Nevertheless, organisations must balance innovational performance and 'normal operations', to sustain current financial performance (Carlisle & McMillan, 2006). Early on, Kanter (1985) recognized this trade-off in more general terms. He investigates the questioned ability of established organisations to innovate. He attributes the problems of established firms to the fact that firms do not recognize the important trade-off between 'administrative management', which focuses on existing activities, and 'entrepreneurial management', intended to bring about change in the organisation. More specifically, March (1991) distinguishes between exploitation and exploration of knowledge. To feed on short-term financial performance, existing knowledge must be exploited to produce incremental improvements and sustain the organisations competitive advantage. In the long-term, organisations must focus on survival. To avoid (creative) destruction, organisations must invest in exploring new knowledge to discover new sources of competitive advantage.

Traditionally, firm innovative behaviour was explained by external demand or technology push. The latter describes how innovation is driven by 'advances in scientific understanding', often facilitated by R&D investments, which determine its direction and rate (Nemet, 2009). The former relates closely to the topic of creative destruction. West (2002) describes how external demand, or threat and uncertainty, may come from different environmental factors: the organisation, market or the direct support system. The level of competition between organisations, or threat in the market, (partly) determines the potential benefits of innovational efforts. Innovative behaviour by a frontrunner in the field is typically highly rewarding, while innovating at the other end of the ranking relates to remarkably lower profits. The level of competition in the market determines which effect dominates. (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005).Workers and organisations will innovate as a response to external demand, in order to strengthen their position in the market. In the tradition of external demand and market pull, there was no room for innovation drivers collaborating or more types of innovation drivers in this linear model, developed in the '70s and mid-'80s (Rothwell, 2002). In research by Di Stefano, Gambardella & Verona (2012), the authors emphasize the importance of demand for innovation drivers paired with firm competences, to be able to adjust and fine-tune technology pushed innovations to the costumers' needs. This matching process shows the importance of combining both types of drivers, to maximize the potential for innovation. Amabile (1988) points

[2] Along with the quoted definition by Baregheh, Rowley & Sambrook (2009), these authors provide a more extensive description of the innovation presented in a diagram (p. 1333). There, ideas are viewed as a means to achieve innovation. Stages of idea creation and idea generation are included in this definition as well.

towards a different category of innovation drivers: motivation to innovate may be derived from a more personal aspect, like a sense of pride from members of the organisation. In this case, innovation is a way for (members of) firms to express themselves.

Given that the literature states that innovation is essential for sustainable firm operations, has this confirmed in empirical research? Heunks (1998) investigates different types of innovation and the relations with various firm outcomes: firm growth, productivity and profits. His findings show that process-, marketing- and R&D innovation contribute to frim growth. Process innovation contributes to increased productivity. These relations are most prevalent in small firms, employing 10 to 50 workers. Product innovation does not contribute to growth, increasing productivity or profits to innovation. Process and marketing innovation also go hand in hand with reduced profits or losses. Two factors may account for this relation. Firstly, innovations require up front investments, which reduce profits. Secondly, low profits may be the reason for a small firm to innovate. Therefore, innovation may be related to reduced profits at first, but provide firm growth in the future. In a more recent research, Hashi & Stojčić (2013) also find a significant positive association between innovation activities and productivity. Their research is very extensive, covering data from about 90.000 firms from Western, Central and Eastern Europe. The authors find that engagement in innovation and innovation output are smaller for larger firms.

In traditional innovation research the focus has been mainly on determinants of innovation on different levels, rather than the social process of idea implementation at the base of innovation within organisations. Although traditional research underemphasizes the importance of this process, it is important to sketch a general picture of how traditional research has approached the topic of innovation and its determinants. Both topics can co-exist; organisational determinants facilitate innovational efforts; a model of individual innovative behaviour within an organisational framework is needed to analyse its association with innovation outputs. The next section will summarize the literature on the determinants of organisational innovation.

2.2 Innovation within organisations

Damanpour (1991) performed a meta-analysis on the contemporaneous state of the literature. The authors distinguish between the moderating effects of the determinants for different types of organisations, types of innovation, stages of adoption (initiation or implementation) and the scope of innovation, covering 13 rather technical organisational determinants. A selection of the general results describes the following associations. Specialization was positively correlated with all aspects of innovation, accept the initiation stage of adoption (non-significant). Centralization has an overall negative effect on aspects of innovation, accept for low scope innovations. A positive managerial attitude toward change was positively associated with both all scopes of innovation. Technical knowledge resources were positively associated with all types of innovation.

Organisations may decide to introduce pay-for-performance measures to incentivize workers to innovate. Yanadori & Cui (2013) discuss the effect of large pay dispersion on workers' behaviour. The authors recognize positive - as well as (unintended) negative consequences of such a policy measure. On the one hand, a strong link between pay and performance provides strong incentives to engage in innovation. Additionally, sorting effects would occur; pay dispersion filters out non-innovative workers while attracting employees with high innovative potential. Negative consequences of pay dispersion involve the low-paid workers to disengage from innovation entirely, thus reducing individual efforts as well as assistance to co-workers. Furthermore, large pay dispersion is associated with high turnover, associated with reduced levels of trust and quality of employee relations. The authors show that the negative consequences dominate the positive ones, thus finding a negative association between pay dispersion and firm innovation. Baumann & Stieglitz (2014) research how high-powered rewards affect innovative behaviour within organisations. The authors emphasize two

factors specific to individual innovation inside an organisation. First, employees face relatively low 'downside risk', worst case scenario, if they decide not to engage in search (i.e. 'start' of innovative behaviour). Additionally, innovation within a firm comes with competition over resources. High-powered incentives thus increase employees efforts in searching, amplifying the competition for organisational resources. As increased competition reduces expected profits, competition dampens innovational incentives. Their findings suggest that both high- and low powered incentives accommodate a small number of radical innovations. Additionally, high-powered incentives provide a too large number of good ideas of incremental innovation, which the organisation cannot all implement. The large number of untouched good, innovative ideas is detrimental to employees' motivation to engage in innovative behaviour in the future. Therefore, the authors argue the case for low powered incentives, providing a 'continuous stream' of good ideas for innovation. Summarizing from the researches by Yanadori & Cui (2013) and Baumann & Stieglitz (2014), accurate monetary incentives for innovation can result in a controlled amount of incremental innovations and a highly capable set of employees. Additionally, Paulus & Yang (2000) argue in favor of individual incentive pay to avoid freeriding in the starting phases of idea generation. Toubia (2006) describes how proper individual incentives can improve the group process of idea generation. On the other hand, pay for performance can disturb the process, by discouraging groups of workers, disturbing team work and bringing up competition too far.

Aside from providing direct incentives for innovation, organisations can affect the innovation process by accommodating a stimulating environment. Shipton, Fay, West, Patterson & Birdi (2005) show that the quality, or sophistication, of HRM practices accurately predicts organisational product innovation and product technology innovation in manufacturing firms. Moreover, they find that a supportive learning climate stimulates organisational innovation. Firms must be careful in executing certain HRM measures. Bammens (2015) performs conceptual research on the relation between individual innovative behaviour and organisational care. Bammens (2015) hypothesizes that care intrusiveness and perceived care insincerity moderates between organisational care and all types of motivation, weakening all positive relations.

The present section nicely illustrates the challenge organisations face in stimulating and accommodating innovative behaviour optimally. The following section will zoom in on the group processes taking place within innovating organisations.

2.3 Group processes

Another important aspect of innovation in organisations is the operation of group processes. In a real life organisational setting, idea generation and implementation will most likely take place in the context of a team or set of co-workers, with a single supervisor. The next section will focus on some of the determinants of team innovation output. Two aspects are discussed: the role of the and group characteristics.

2.3.1 The role of leadership style and traits

A supervisor, or group leader, can affect a group in (at least) two manners: behaviour and personal traits. Consistent behaviour translates to a leadership or management style. One particular leadership style has received much attention over the past few years: transformational leadership (TL), in which research has progressed to tests of its empirical validity across various settings (e.g Price & Weiss, 2013; Turnnidge & Côté, 2016; Thomson, Rawson, Slade & Bledsoe, 2016).The focus of transformational leaders is 'to broaden and elevate the interests' of employees, make employees aware of the organisational vision and align individual-, group- , and organisational interests. Leadership is characterized by charisma, inspiration, intellectual stimulation and individualized consideration (Bass & Riggio, 2006). Li, Mitchell & Boyle (2016) look its consequences for individual and team

innovation, in response to inconsistent evidence in past research. The authors describe a differential effect of TL in teams on innovation outcomes of the group- and individual level. TL is hypothesized to stimulate individual innovation, while affecting group outcomes by emphasizing group identity, communicating inspirational vision and stimulating team building, all discouraging the individual to develop and implement own ideas. The authors introduce task interdependence to play a crucial role: the extent to which individual activity (positively) affects other team members' success. Thus, high task interdependence diminishes the negative effect of TL in a group context on individual innovation. The authors find a positive association between group-level transformational leadership and team innovation outcomes, strengthened by high group task interdependence.

Aside from leadership style, other traits of a leader are important for group innovation (e.g. Aronson, Reilly & Lynn, 2006; Černe, Jaklič & Škerlavaj, 2013). Recent research by Madrid, Totterdell, Niven & Barros (2016) focuses on the relation between a relatively new dimension of (leader) personality, affective presence, and team innovation. Affective presence is an interpersonal trait: the tendency of an individual to make the people around feel similarly positive or negative, although feelings may differ between the leader and the employee. The author finds that positive leader affective presence encourages information sharing within the team, mediating the positive association with team innovation output. Additionally, the authors look at the relative importance of leader affective presence. Their findings suggest that leader positive affective presence is a stronger predictor of team innovation than leader positive affect, intellectual stimulation and relational transparency. In the light of research on transformational leadership, this is a very interesting finding. The case of negative affective presence is not as strong, showing only weak relations.

The factors that are discussed here are only a selection of traits. Discussing the full set is beyond the scope of my research and rather irrelevant to this study. From this section, I conclude that leader(ship) traits can affect innovation outcomes. Leaders can stimulate innovation if they contribute to the 'right' environment.

2.3.2 Group characteristics

Next, the focus turns to team characteristics. The next two studies by Hülsheger, Anderson & Salgado (2009) and Somech & Drach-Zahavy (2013) also touch upon the role of creativity in the innovation process. The role of creativity will be discussed in section 2.5.2, the main focus for now is on the context variables of teams. Hülsheger, Anderson & Salgado (2009) perform an extensive meta-analysis on determinants of creativity and innovation on the team-level. The authors distinguish between team process variables and input variables, as labelled in Table 1.

Team process variables	Team cohesion, communication patterns, vision, participative safety, support for innovation, task orientation, task- and relationship conflict.
Input variables	Composition and structural characteristics: team member diversity, team size, tenure, task - and goal interdependence.

Table 1: team variables, as categorized by Hülsheger, Anderson & Salgado (2009)

Their results show that the team process variables vision, support for innovation, external communication and task orientation show the strongest relation to team innovation. The input variables show weaker coefficients. Somech & Drach-Zahavy (2013) take a somewhat similar approach. The authors research innovation as a process by separating the idea generation stage from the implementation stage. They hypothesize that team composition, determined by 'aggregated individual creative personality and functional heterogeneity', affects creativity on the team level, similar to Hülsheger, Anderson & Salgado's (2009) input variables. Somech & Drach-Zahavy (2013)

show that team creativity positively affects innovation implementation. The authors emphasize how their results show the importance of organisational climate; team creativity only translates into improved innovation implementation when the climate for innovation is high. Hence, some of the patterns in organisational innovation process extend to the team innovation process.

Related to some of these team process variables, Peralta, Lopes, Gilson, Lourenço & Pais (2015) empirically show the importance and potential benefits of active involvement in innovation for teams. The authors discuss how certain emergent state variables moderate the association between team innovation efforts and team effectiveness, measured as performance (1) and reputation (2) outcomes. The first, confirmed, hypothesis states that the emergent states of team goal commitment and clarity stimulate the motivation for innovation by aligning interests and behaviours of team members, thus increasing performance. The second hypothesis states that team affective tone moderates between the innovation processes and team reputation through judgements induced by feelings of third parties. The authors could only establish that negative team affect mediates the relation, pointing at a negativity bias. This research by Peralta, Lopes, Gilson, Lourenço & Pais (2015) takes a first step toward my topic of reputational concerns; reputation can be a motivational antecedent in innovation. Comparing the emergent states of Peralta, Lopes, Gilson, Lourenço & Pais (2015) to the team process variables of Hülsheger, Anderson & Salgado (2009), they are closely tied. 'Correct settings' on the team process variables are important for innovational team performance, as well as team reputation.

From section 2.2 and 2.3, one might argue that firms are capable of creating an environment fit for innovation, if only they try hard enough with the correct approach. Is it a realistic idea that innovation can be optimized through creation of the 'perfect' environment? For example, the literature proposes team coaching and stimulation of team reflexivity to increase innovational outputs (Rousseau, Aubé & Tremblay, 2013; Schippers, West & Dawson, 2015, Hoegl & Parboteeah, 2006). Given a fixed group of workers in a specific work environment, the manager will have to make the best of his team's cumulative skillset. The mentioned activities are costly and may require adjusted or new firm policy. Hiring a new employee to contribute to the input – or team process variable may be at the bottom of the priority list, depending on firm policy. The manager could potentially adjust his leadership style to a more transformational one, though this type of leadership comes much more natural to certain personality types (e.g. Brandt & Edinger, 2015) and therefore, it can be a tough transition for some managers. Thus, shaping the environment to its optimal form may be a more rigid process than it seems at first glance. Some tweaks may be easily completed. Realistically, it is difficult, or impossible, for managers to master and apply the proper techniques to drastically change the environment and optimize innovative behaviour.

2.4 Innovation and the individual

The determinants of organisational and team innovations that are discussed so far mainly focus on the environment that is provided by the organisation. Environmental aspects are only one side of the story. Bharadwaj & Menon (2000) examine the organisational innovation hypothesis. This hypothesis states that innovation is determined by a function of organisational systems, designed to facilitate creativity and innovation, and individual effort. These organisational systems take the form of resources, tools and formal approaches in favor of creativity as well as an encouraging environment. In their model, creativity is perceived as 'property of thought process', which can be improved upon through training and practice. To be clear, these authors do not traditionally view creativity as a personal trait, but more like a skill that can be attained. Bharadwaj & Menon (2000) find support for the organisational innovation hypothesis, showing that the presence of both appropriate organisational systems and individual effort results in the highest levels of organisational innovation. Moreover, organisational creativity systems show a strong relation to superior innovative performance, even

when individual effort levels are rather low. Therefore, aside from environmental aspects, individual inputs are vital to organisational innovation performance.

The next section will focus mainly on the perceived most important individual innovation input: creativity, because, in general, creativity is perceived as crucial for individual innovation. First, I will summarize the literature on other individual factors in innovation.

2.4.1 Individual innovation inputs

In the previous section, the relevance of the leader and leadership style, team characteristics and climate for innovation was established for innovation in teams. Scott & Bruce (1994) recognize these aspects, and add to these, in the development of a model of individual innovative behaviour. The authors argue that certain individual factors directly affect innovative behaviour, or potentially change the perception of the innovation climate. Intuitive problem-solving was indirectly positively associated with innovative behaviour, while systematic problem-solving was directly, negatively associated with innovative behaviour. Another factor may be the need for cognition, a worker's 'tendency to engage in and enjoy thinking'. Wu, Parker & De Jong (2014) discuss how the need for cognition can be a motivation to engage in innovative behaviour, when a worker is faced with low levels of job autonomy and time pressure. In the absence of such external innovation drivers, personality traits have the opportunity to surface as stimuli for innovation.

When considering the need for cognition and work engagement, both relate to individual innovation efforts in their own manner. While the latter is a prerequisite, the former may act as a source of intrinsic motivation. Intrinsic motivation is vital to innovation, as described by Chen, Fahr, Campbell-Bush, Wu & Wu (2013). Their results show how types of motivational states of workers interact with team support for innovation, and both individually and jointly affect individual innovation performance within teams. Workers' self-efficacy, confidence in own relevant capacities, and intrinsic motivation are shown to mediate the positive relation between a proactive personality and innovative performance. A supportive team environment, again, also promotes innovative behaviour. In turn, individual innovative behaviour improves team support for innovation.

Organisational innovation may be far beyond the worker's perspective of their added value. As described by Van de Ven (1986), the innovation process within organisation is often overcomplicated, causing workers to lose sight of what their efforts to contribute amount to. Janssen (2000) describes how job demands for innovation only translate to increased effort in innovation when workers perceive the reward for their efforts to be a fair one. Disruptions in communications that lead to suboptimal, or 'unfair' outcomes, may be detrimental to future innovation efforts.

2.4.2 Creativity and innovation

The next subsection focuses on the subject of creativity. Research by Bharadwaj & Menon (2000) on the organisational innovation hypothesis has provided a first glimpse of the relevance of creativity for innovation. First, a more extensive overview of the range of definitions and its relevancy for innovation will be provided, followed by a short overview of some determinants of creativity.

The field has constructed plenty definitions of creativity. Amabile (1983) defines creativity as the extent to which a response to a particular task is novel and valuable, useful, appropriate or correct. Oldham & Cummings (1996) describe how some definitions require product output to establish creativity, while others leave room for ideas or even dreams to be creative. The most important distinction the authors make is whether creativity is regarded as an achievement, disposition or attitude, or an innate ability. Additionally, Csikszentmihalyi (2014) argues that the individual cannot be isolated from its environment where creativity is concerned. He identifies three important factors: social institutions, cultural domain and the individual. Creativity of is the result of interaction between these factors. A cultural domain is necessary to establish the novelty of the idea, while effectiveness,

or usefulness, is derived from the social environment. Hence creativity does not prevail in an individual alone; creativity is derived from the environment.

Early on, Amabile (1988) emphasizes the role of the process of individual creativity in organisational innovation. The organisational innovation hypothesis recognizes the importance of individual effort and creativity in the innovation process (Bharadwaj & Menon, 2000). Scott & Bruce (1994) have gone as far as stating that the difference between creativity and innovation is a matter of emphasis, instead of substance. Research on the association between creativity and innovation has shown some conflicting results. Results seem to depend on firm size, type of innovation and firm maturity (Heunks, 1998). Sarooghi, Libaers & Burkemper (2015) recognize the conflicting evidence that emerges from prior research and hence perform an extensive meta-analysis. Specifically, they look at the role of environmental, cultural and organisational factors in the relation between innovation and creativity. They consider this relation on different levels: the firm -, team -, and individual level. Overall, results show a strong positive relation between creativity and innovation, though the correlation proved to be strongest on the individual level ($r=0.60 > r=0.38 > r=0.30$). The relation between creativity and innovation is even stronger for larger firms, process innovations and low-tech industries.

The past (early) literature has undoubtedly focussed most of its attention on how individual traits supposedly determine individual creativity, investigating whether 'the creative individual' exists. Many, many studies have been done on the associations between individual creativity and the Big Five personality traits. The literature seems to have reached an agreement on the relation between openness to experience (+) and extraversion (+), and creativity. (Sen & Hagtvet, 1993; McCrae, 1987; King, Walker & Broyles, 1996; George & Zhou, 2001; Wolfradt & Pretz, 2001; Reiter-Palmon, Illies & Kobe-Cross, 2009; Baas, Roskes, Sligte, Nijstad & De Dreu, 2013) The discussion on conscientiousness and creativity is still on-going; an illustration of the challenges that arise from research on sources and antecedents of creativity. An often mentioned 'determinant' of individual creativity is intelligence. At the basis of the hypothesized relation between intelligence and creativity is the theory of Guilford (1956, 1959) on the structure and different facets of intelligence. A single aspect, divergent thinking, has often been associated with creativity. Silvia (2015) characterizes the association between intelligence and creativity as two capabilities of the mind, belonging to a large family of possibilities. In this fashion, intelligence and creativity may not always be distinct in terms of how both contribute to performance on a certain task separately. Early research found that although a certain level of intelligence is required for creative performance, intelligence scores explain only a small part of the variance. (Batey & Furnham, 2006) Jauk, Benedek, Dunst & Neubauer (2013) empirically test the threshold hypothesis for creative potential as well as - achievement. The authors establish significant thresholds for creative potential only; intelligence increases creative achievement for all IQ-levels, thus rejecting a threshold. These 'sources' of creativity, in their own context, are only part of the picture. A discussion of the full picture is beyond the scope of this research. Nonetheless, it is important to understand that people differ in creativity; unique sets of characteristics in unique personal environments imply different creativity levels for everyone.

So far, creativity is portrayed as a strict positive asset for firms. Nevertheless, research has shown potential costs of these incentives. Gino & Ariely (2012) discuss how (stimulating) creativity may lead to workers being more dishonest. Creative workers may be more capable of making up excuses to justify their actions, leading to unethical behaviour. Results show that creative participants are more dishonest and have a higher tendency to engage in unethical behaviour. Baucus, Norton, Baucus & Human (2008) describe how unintended consequences of creativity stimulation are often overlooked by research as well as practice. The authors summarize past research on creativity stimulation and categorize the conventional policy measures into four types: increased risk taking, challenging authority and avoiding tradition; breaking rules and standard operating procedures and

finally, creating conflict, competition and stress. Can firms counteract unintended consequences by prevention or adequate responses? The most prevalent organisational response is as follows: firms need to thoroughly inform their workers about the firm's identity and operations, to convey information on firm's ethics. This information helps workers to behave in the best interest of the firm and make proper decisions, reducing unethical behaviour. Thus, firms can gain from stimulating creativity, if they take a complete set of measures. If potential unintended consequences are ignored, additional costs can be substantial.

Thus far, the literature review has provided a large array of factors that have the potential to affect innovational output. Nevertheless, creativity is not a simple sum of all individual 'creative traits', qualities of the leader, environmental support and intelligence, due to their interdependencies (e.g. George & Zhou, 2001; Jauk, Benedek, Dunst & Neubauer, 2013). Thus, creativity stimulation is a relentless process with potentially high costs and uncertain benefits.

2.5 Stages of innovation

The present section will take the next step towards the construction of a model of innovation implementation by discussing a more technical aspect of innovation: the components of the innovation process. Across time, many authors have structured the phases of the innovation process in their own fashion, leading to a variety of descriptions in terms of both the number of phases, as well as perspectives (e.g. Usher, 1955; Cummings & O'Connell, 1978; Kanter, 2000; Dreiling & Recker, 2013). The phases are described by Perry-Smith & Mannucci (2015) as follows: 1. idea generation, 2. idea elaboration, 3. idea championing, 4. idea implementation; comprehensive, while clearly distinguished. These authors discuss how for each phase, different skills and circumstances are needed to bring the idea to completion. Some of these elements, that are required for one phase, can be harmful in other phases. I will briefly discuss the four phases of the traditional innovation stage model and some of the required elements, as suggested by Perry-Smith & Mannucci (2015).

2.5.1 The traditional innovation stage model

In the first phase of innovation, *idea generation*, a worker produces a number of novel, useful ideas and selects the one he has the most faith in, or believes to have the highest value. Perry-Smith & Mannucci (2015) describe how the idea generation process requires cognitive flexibility, which allows for accepting and integrating new information, while shifting between cognitive categories. A prominent issue in past research involves how innovation stimulating measures focus mainly on raising idea quantity rather than quality. Stimulating idea quantity in an attempt to raise quality may have a counteractive effect; the diminishing returns hypothesis states that the higher quantity of ideas a certain group produces, the lower idea quality. This hypothesis is confirmed several times in the literature. (Reinig & Briggs, 2008; Kazakci, Gillier, Piat & Hatchuel, 2015)

The second phase of innovation comprises of *idea elaboration*. In this stage, a worker systematically evaluates and adjusts his idea accordingly, until he values it to be good enough to share with others. The idea has develops from a vague thought to a solid concept. Inconsistencies are eliminated. Constructive feedback from the environment is necessary to help the worker to develop and improve the idea. The process is meant to clarify the potential of the idea to the worker. Perry-Smith & Mannucci (2015) describe how workers in the elaboration process are in need of emotional support to deal with the uncertainty that comes with development of an idea. The higher the novelty of an idea, the higher the potential benefits are. However, the higher the novelty, the more risk the worker has to deal with.

In third phase, *idea championing*, the worker tries to gather support from his principal through actively promoting his idea, hoping to gain approval and other resources for the future stage of implementation. In order to succeed at receiving this approval, the worker needs influence to convince

their principal that the idea is a winner, and legitimacy to signal the quality and potential of the idea. (Perry-Smith & Mannucci, 2015) If the worker fails to gather support for his idea, the process stalls and ultimately ends, at least for now.

The final stage is *idea implementation*. Perry-Smith & Mannucci (2015) distinguish two sub-phases in implementation: production and impact. In the first sub-phase, the concept is put into production, resulting in a blueprint of the finalized idea. Relevant team members are introduced to the novelty. In the second sub-phase, impact, the idea has to be accepted, recognized and used. This is a process of social systems judging the novelty and value of the innovation. Both sub-phases benefit from shared vision, a common understanding of the value of the innovation. Implementation is not typically distinguished in two sub-phases, where most researchers leave out the production phase. (i.e. Klein & Sorra, 1996)

Each stage has its own optimal conditions. For example, Perry-Smith & Mannucci (2015) discuss the aspect of social networks in innovation and state that, in each phase, workers need to make use of different parts of their social networks. In the idea generation stage, weak ties are useful to gain new knowledge, while strong ties are beneficial for the phase of idea elaboration. Some optimal conditions are even conflicting across stages. Rank, Pace & Frese (2004) describe how creativity in the idea generation stage thrives in an environment with low uncertainty avoidance, individualism and power distance, though implementation is most successful when these variables take moderate levels. These conflicting factors are examples of the challenges a worker with a great idea faces. Implementing an innovation is much harder than just coming up with something smart.

2.5.2 Beyond the traditional model

The traditional approach in studying innovation typically involves looking at the influential factors of innovation, suggesting some success-increasing tactics or trying to categorize the innovation process in distinct phases. Combining these methods has given a good illustration of the complexity of the process. Researchers have yet been successful at capturing all these elements in a single model. As early described by Saren (1984), most studies attempt to categorize the innovation process and focus their research on a single stage. Findings are dependent on the chosen approach, making it difficult to create a generalized model. Aside from this, Saren (1984) describes an even more prominent issue; most of the models do not focus on the internal innovation process within firms. The models try to capture the general process of innovation and overlook some of the direct issues that prevail in the construction of a model of firm innovation. Saren (1984) argues that more research is necessary on the nature of the innovation process within the firm.

In studying the innovation process, most research assumes the decision process to take its most efficient form. Workers are expected to bring forward their best idea and provide all available information. The supervisor is assumed to be capable of, and incentivised to make the optimal, profit-maximizing decision, ignoring any individual or social process disturbing efficiency. Is this a realistic view? Which factors may disrupt this decision process? Most issues arise from agency problems, on different levels. First of all, actors (supervisors as well as workers) may not behave according to firm goals through a lack of commitment, leading to disinterest and slacking off. In this case, workers are victimized, if not made aware of the specific behaviour that is expected from them. Secondly, worker or supervisor may not be aware of how to act according to the firm's vision, leading to unintentional adverse behaviour or a lack of pro-active behaviour. Disturbances may also arise from group processes. A supervisor may be sensitive to manipulation by workers, leading to sub-optimal decisions. Or, the supervisor may have a personal preference for the idea of a worker for other reasons then quality of the idea; friendship or another personal connection. Due to resource constraints, idea selection in innovation becomes a tournament amongst workers, in which only a limited number of players can win. This process can lead to adverse behaviour by workers attempting to increase their

odds of winning; on the contrary, team members may decide to start cooperating. The outcome will be determined by how team goals are formulated (Stanne, Johnson & Johnson, 1999). Another factor that is important to (most) workers is their reputation. Pride workers may attach high value to selection of their idea and improve their reputation as a valuable asset to the firm. External constraints may also disturb the implementation process. Fleuren, Wiefferink & Paulussen (2004) show how time-constraints lead to lower levels of dedication to new innovations. Time-constraints may lead to side-stepping of more radical innovations. If pressure from outside the team rises too high, in terms of time or resources, workers may decide to explore their outside options; selling their idea, or investing in individual innovation. In this case, organisations miss out on potentially rewarding innovations.

2.6 Incentives in individual innovative behaviour

The black box of the implementation decision brings about many questions. How does a supervisor decide between different ideas that are offered to him? What determines whether a worker proposes his idea? How do workers deal with competition over implementation? Again, most research approaches the issue from the efficiency-oriented perspective, as described by Yuan & Woodman (2010). As the implementation process involves a range of actors with their own interests, –not exclusively the firm's-, the implementation process may follow an alternative path. Strikingly though, no model has been developed to capture this social process within firms. My research will attempt to make a small contribution to this, to capture attention for this gap in existing research.

Most of the research that does focus on the conversion of idea to innovation describes how actors can improve their success rate. This tendency shows at each level of analysis; firms can increase their implementation success by providing 'the' optimal levels of monetary compensation (dispersion), creating the right firm culture, gaining innovation experience, a matrix organisation structure, etc. (Yanadori & Cui, 2013, Baumann & Stieglitz, 2014; Van der Panne, Van Beers & Kleinknecht, 2003). Taking the perspective of innovation characteristics, relative advantage and complexity are the most important determinants of successful implementation (Tornatzky & Klein, 1982). Klein & Sorra (1996) emphasize the role of organisational climate and the fit between innovation and values of the targeted consumers. On the level of individual innovation, Baer (2012) discusses the role of motivation and personal networks in the relation between the production of ideas and their implementation. He, too, wonders how factors other than quality of the ideas play a role and describes how research has rarely investigated the conditions under which ideas lead to real innovations. The author describes how more creative ideas bring about more risk and lower adoption rates. Therefore, antecedents of creativity and innovation implementation may be very different. Baer (2012) recognizes that innovation is a socio-political process. Thus, workers may engage in the risky behaviour of influencing, given they have the appropriate network to gather support from. The author labels this motivation as 'implementation instrumentality', which is dependent on the expected outcome of his behaviour. Importantly, these expected outcomes may go beyond monetary compensation. An alternative motivational antecedent of innovation may thus include image gains, forming a connection to my topic of relational concerns. Baer's (2012) findings indicate that implementation instrumentality was the strongest moderator between creativity and implementation, suggesting that workers can increase their odds of implementation if they are motivated to do so.

A very distinct difference between these studies and my research is that these authors take a rather normative approach to this problem. This research attempts to uncover the nature of implementation in the innovation process, focussing on a single part of decision-making, thus takes a more descriptive approach, attempting to map a limited set of aspects of the process that takes place on the work floor every day. The focus will be on one aspect of the social process of idea selection: the role of personal reputation. As suggested by Baer (2012), reputation can increase potential gains of

idea implementation. Before discussing the elevated gains from reputational in idea implementation and how these shape incentives for workers, a general discussion of reputation is provided.

As stated in the introduction, reputational concerns occur when an agent worries about the influence of his actions on the perception of the principal (Suurmond, Swank & Visser, 2004). Hagen & Hammerstein (2006) argue that any game with personal interaction sets psychological machinery into play, giving rise to reputational concerns for behaviour. The literature reveals an intricate picture of reputation. Paradoxically, the most important actors in reputation building are not the holders of reputation. Carter, Bitting & Ghorbani (2002) discuss how reputation is based on to what extent an audience believes a person to have fulfilled expectations or his social role. Hence, no audience, no reputation. Ferris et al (2003) provide a more extensive characterization: reputation as an identity derived from the worker's salient personal characteristics, accomplishments, behaviour and intentionally presented images, either informed about through own observations or received communication. Thus, one worker may have different reputations with each audience member. Another key characterization of reputation is its multidimensional nature. Zinko, Gentry & Laird (2016) develop a multidimensional personal reputation scale, to capture reputation on the task -, social - and integrity dimension. Each dimension comes with its own antecedents and benefits.

Sanfey (2007) describes how traditional behavioural models of game theory fail to accurately describe behaviour; people act less strategic than models predict and seem to care about social values. The role of reputation in Game Theory is the most often used modelled in the Ultimatum Game. Models in Game Theory give room to consequential, social interaction, allowing to research notions of equality, cooperation and trust, and reputation; Nowak, Page & Sigmund (2000) propose an Ultimatum game in which players have access to information on the behavioural history of the other player. Now, reputation becomes important; accepting a low offer could induce the next proposer to reduce his offer. In the presence of reputational concerns, it is optimal for the responder to reject low offers, in order to gain a reputation to only accept higher offers. Hence reputation is a valuable asset.

2.7 Reputational concerns in individual innovation

The setting of the present research includes a team of workers and a single supervisor that decides on the adoption of a limited number of ideas. Workers may engage in certain types of individual innovative behaviour, suggested by Holman, Totterdell, Axtell, Stride & Port (2005): idea generation and idea promotion. Van de Ven (1986) describes idea promotion and implementation as a socio-political process. The socio-political view focuses on how innovative actions are signals to the environment and provide opportunities for gains beyond the traditional efficiency perspective (Yuan & Woodman, 2010). Innovative behaviour has a symbolic meaning to team members, affecting their perception of the co-worker (Yuan & Woodman, 2010). Aside from image gains, innovative behaviour is hypothesized to increase expected performance outcomes, through higher work quality, increased productivity, a lower error rate, and improved general job performance (Cingöz & Akdoğan, 2011). These additional benefits may act as motivational antecedents to individual innovative behaviour.

Yuan & Woodman (2010) describe how outcome expectations, for performance as well as image, affect individual innovative behaviour. Their findings show the hypothesized positive relation between expected performance outcomes and innovative behaviour, as well as a negative association between expected image risks and innovative behaviour. The former finding fits with the efficiency-approach, while the latter fits into the social-political perspective on innovation. A significant negative relation between expected image gains and innovative behaviour is established, which can be explained by the research method. Innovative behaviour is rated by supervisors, rather than by the worker himself; workers may engage in innovative behaviour to show off rather than having clear intentions of making a difference, when expected image gains are high. Supervisors may spot this bragging rather than innovating behaviour and reward the workers with low scores. Cingöz &

Akdoğan (2011) transport the research question of Yuan & Woodman (2010) to a sample of private corporations that operate in Turkey. Their findings do show a significant positive relation between expected image gains and innovative behaviour. An important difference between these two studies is that Cingöz & Akdoğan (2011) use data retrieved from questionnaires, in which workers rate their own innovative behaviour. This could be a cue in favour or the explanation by Yuan & Woodman (2010), stating that high expected image outcomes lead to 'empty' innovative behaviour.

Yuan & Woodman (2010) state that certain factors affect how workers believe innovative behaviour and performance and image outcomes to be related. They specifically look at five factors of these certain factors, one of which: reputation as innovative. Yuan & Woodman (2010) hypothesize that workers with a higher reputation as being innovative believe the potential performance improvement to be higher; expected image risks are also higher for those with a good reputation, hypothetically. Results confirm that workers with a reputation as innovative estimate higher expected performance outcomes. The results show no significant relation between an innovative reputation and expected image risks. The authors suggest that two mechanisms may cancel each other out. Firstly, innovative behaviour is expected from workers with an innovative reputation, reducing concerns about not fitting their social image, therefore reducing expected image risks. On the other hand, this reputation of being innovative may concern the worker, as he will more likely be perceived as an instigator, resulting in irritation or frustration of team members and inevitably, reputation damage; higher expected image risk. Thus, more research is needed on this association.

In a broader sense, research on the individual's direct motives to engage in innovative behaviour is rare. Therefore, the present research constructs a highly simplified model of the supervisor's adoption decision, providing testable hypotheses for future research. Additionally, the model introduces reputational concerns as a source of incentives aside from monetary rewards and costs of innovative efforts. To be able to construct a model of reputational concerns in innovation, it is important to summarize and clarify the incentives that stem from reputational concerns. Yuan & Woodman (2010) mention some gains of good (innovative) reputation: additional resources and future social support. Reputation loss can come at high cost, when co-workers and supervisors derive information from reputation: loss of social legitimacy; risks for promotion, a potential raise, or new project-assignments (Edmondson,1999; Boogenrieder & Nooteboom, 2004).

Zinko, Gentry & Laird (2016) take a more technical approach. Section 2.6 demonstrated their multidimensional model of reputation. In this research, the authors also discuss how perceived outstanding performance in tasks, interaction, or integer behaviour will affect certain outcomes. In the dimension of task proficiency, a worker can improve his level of skill to boost his reputation. A reputation in task proficiency will raise expectations based on past performance and provide increased autonomy. In the dimension of social reputation, reputation will be determined by how interactions with the environment fit the social norms of the group. Positive changes in social reputation are associated with increased confidence and trust of the audience, higher social status and more power. The dimension of integrity is somewhat more complicated. Consider a worker performing a specific action on the work floor. The audience compares their perceptions of an action (or perceptions of communication of this action) to the action history of the worker to understand the motivations behind this action. To do this, they need to keep in mind the integrity of the person. The integrity dimension is more universal than the other dimensions of reputation. Where task reputation only holds for a specific task, integrity reputation extends to all decisions the worker faces. Zinko, Gentry & Laird (2016) describe how a high integrity reputation will extend to higher autonomy and trust.

A threat to either the task -, social – or integrity dimension will give rise to reputational concerns, only when a worker is accountable for his actions (De Cremer & Tyler, 2005). These concerns will induce changes for individual's behaviour. At the same time, holding a certain

reputation will have consequences for behaviour as well: reputation gives rise to expectations, which workers will try to fulfil, in order to maintain their level of reputation.

3 Analysis

The analysis first introduces a model of innovation in a setting without any differential incentives. Then, reputational concerns are introduced to analyse whether these concerns could disturb the implementation process. In a search for symmetric Nash equilibria in pure strategies, three types of motivational antecedents for workers are specified: reputational gains, effort cost and project pay offs. In the final section of the analysis, the presence of multiple equilibria is established.

3.1 The basic model

The model includes three actors on two distinct levels of hierarchy: two employees and a single supervisor. Each worker comes up with a single idea; only one of the ideas is implemented. Ultimately, the supervisor has to decide on the implementation of a specific idea; (cheap) resource constraints of the firm reserve the supervisor from implementing multiple innovations. All workers face the same monetary incentives for innovation; the rewards of the innovation project are shared equally among actors.

Individuals are heterogeneous in terms of creative ability: some are able to come up with more creative ideas. From the literature, it is clear that creativity of the idea and internal creativity of the person are connected though not equivalents. Nevertheless, I assume this to be the case. Creative ability is captured by *c*. For the sake of simplicity, I assume this variable to be binary; a worker is assigned to have either high or low creative ability.

$$c = \begin{cases} c_L, & if\, 1-\alpha \\ c_H, & if\, \alpha \end{cases}$$

I assume creative ability to be independently distributed across the full population of workers. Therefore, both workers can be of the same type, or one of the workers has higher creative ability than his colleague. The supervisor cannot observe whether the worker has high or low creative ability.

In the first stage, all individuals get an idea. Workers are perfectly aware of their own creativity, but cannot observe their co-worker's creative ability level.. I assume that workers determine their strategy by weighting expected project revenue, which is equal to the creative ability level of the employee who generated the implemented idea.

The capacity to implement ideas is limited; only one idea can be implemented. The revenue will be equally shared amongst the workers and the supervisor, providing the following distribution.

$$R_n = c_n$$

$$\left(\pi_i = \pi_j = \pi_S = \frac{1}{3}R \middle| t = 3\right)$$

In the following phases, communication takes place. Each worker provides the supervisor with a signal s. This signal depends on two parts: creative ability of the worker and an additional bias b. In the second stage, the worker decides on whether to exert effort. The worker can attempt to virtually 'inflate' his creative ability by exerting effort to send a misguiding signal, though exerting effort is costly. I assume that the costs of effort are equal for both workers, $\theta = \theta_i = \theta_j > 0$. Through the signal, the worker can try to convince him to choose his idea over the idea of his co-worker. Effort allocation is modelled as a binary choice; a worker exerts effort to manipulate his signal, or chooses not to and accurately signals his creative ability.

$$\mathrm{s}\,(s_i, s_j) = \mathrm{c} + \mathrm{b}$$

$$b = \begin{cases} 1, & pe \\ 0, & 1-pe \end{cases}$$

$$0 \leq p \leq 1$$

$$s_{c_L+b} = s_{c_H}\ and\ c_L + b = c_H, if\ b = 1$$

The distribution of b is intuitively self-evident. If the low ability agent exerts effort, so $e = 1$, he can attempt to signal high ability. With a chance of p, effort translates into a high signal, convincing his supervisor that he has high creative ability, c_H. With a chance of (1-p), his signal does not affect the supervisor in any way, leading him to continuously believe that his worker is a low creative ability worker. In this case, the worker incurs the cost of effort without the rewards. If he decides not to exert effort, he sends a low ability signal. The high ability worker does not need to exert additional effort to send a high signal. As effort is costly, a high creative ability worker will thus choose not to do so. I exclude the option of putting effort into signalling for workers with high creative ability, in the basic model. In the next section, the model will be adjusted to allow for this option.

In the third stage, creative abilities and effort levels from both workers merge into a signal to the supervisor. As stated before, the supervisor cannot distinguish between accurate and deceptive signals. In the fourth stage, the supervisor chooses which idea is implemented. Thus, his (pure) strategy set D(c) is as follows.

$$D(c) = \{c_i, c_j\}$$

The supervisor must base his decision on the signals he has received. The signal is a binary variable, representing a front of low or high ability. The following equation shows how the two signals can arise.

$$s = \begin{cases} s_L, & if\ c = c_L and\ e = 0, or\ with\ chance\ (1-p)\ if\ c = c_L\ and\ e = 1 \\ s_H, & if\ c = c_H and\ e = 0, or\ with\ chance\ p\ if\ c = c_L\ and\ e = 1 \end{cases}$$

The expected payoff of choosing an idea is derived from the signal; the supervisor is unaware of the creative ability of the selected idea creator. The supervisor has to make his implementation decision based on the received signals, as it is the only information provided to the supervisor.

$$E(R) = c, \qquad c(c_{L,} c_H)$$

After project implementation, co-workers rely on implementation information to adjust the reputation of the idea generator. Realization of payoffs happens after the benefits of good reputation have been incurred.

All actors optimize their utility U, that is derived from the payoff of the selected creative idea c, while negative utility is derived from exerting effort e. The variable I represents whether idea c was created by the worker himself. B reflects the role of reputation in this model. For now, it is assumed that $B_i = B_j = 0$. The supervisor derives utility from the project payoff only.

$$U_i = \frac{1}{3} R + I_i B_i - \theta e_i$$

$$U_s = \frac{1}{3} R$$

The next section will focus on solving the basic model.

3.1.1 Solving the basic model

The extended form is represented in the game tree in Figure 1.a. The grey lines represent a low signal; the black lines represent high ability signals. It is a sequential game: first, workers decide on their effort-level, and then supervisors make the implementation decision. Backward induction will be used to solve the game, starting from the implementation decision by the supervisor. The figure illustrates the four different scenarios for the supervisor, indicated by superscript on S, indicating the decision of the supervisor.

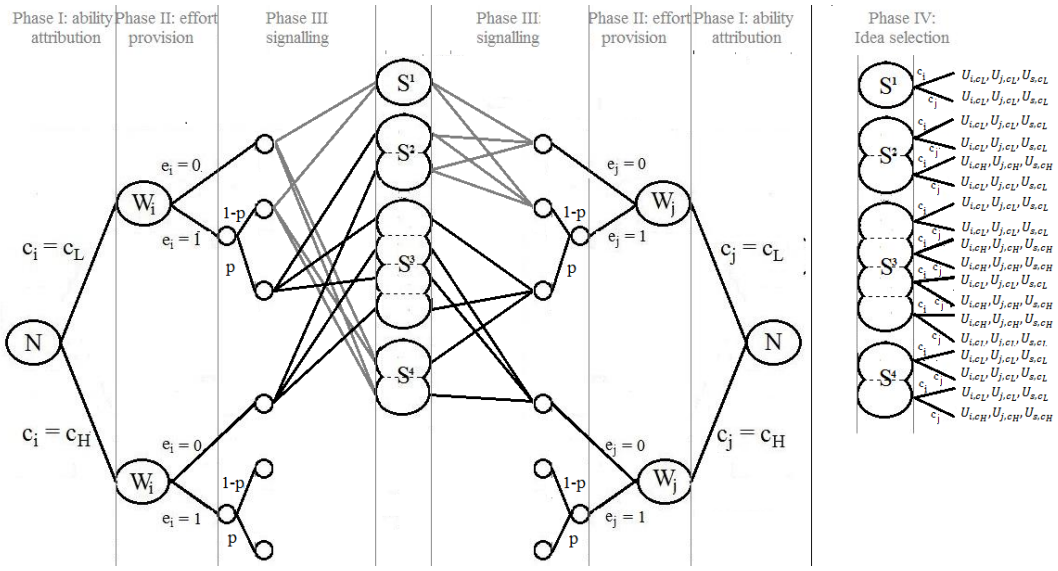

Figure 1.a: The extended form of the basic game

Scenario 1

In the first scenario, the supervisor receives two signals of low creative ability. The supervisor knows that these signals must be accurate: either the workers did not put effort into signalling, or the signals failed to reach him. The supervisor yields utility from choosing either idea as follows.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_L}) = \frac{1}{3}c_L$$

$$\mathrm{E}(U_s|\mathrm{s}_{j,c_L}) = \frac{1}{3}c_L$$

$$\mathrm{E}\big(U_s|s_{i,c_L}\big) = \mathrm{E}\big(U_s|s_{j,c_L}\big)$$

Thus, the supervisor is indifferent between choosing either idea and will randomly select one idea for implementation.

$$D(c) = \big(c_i, c_j\big)\ with\ \left(\frac{1}{2}, \frac{1}{2}\right)$$

Scenario 2

In scenario 2, the supervisor receives a high ability signal from worker i, while receiving a low ability signal from worker j.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H}) = (1-\alpha) * \frac{1}{3}c_L + \alpha * \frac{1}{3}c_H$$

$$\mathrm{E}(U_s|\mathrm{s}_{j,c_L}) = \frac{1}{3}c_L$$

$$E(U_s|\mathrm{s}_{i,c_H}) > \mathrm{E}(U_s|\mathrm{s}_{j,c_L})$$

Since $\alpha < 0$, the expected utility of worker i's idea is higher. Therefore, the supervisor will decide to implement the idea of worker i.

$$D(c) = c_i$$

Scenario 2 is the inverse of scenario 4; in this final scenario, worker j will achieve implementation after sending a high creative ability signal, given that worker i does not exert effort to signal.

Scenario 3

In the third scenario, the supervisor receives two signals of high creative ability. The expected utility levels for selecting and implementing either idea are as follows.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H}) = (1-\alpha)p\frac{1}{3}c_L + \alpha\frac{1}{3}c_H$$
$$\mathrm{E}(U_s|\mathrm{s}_{j,c_H}) = (1-\alpha)p\frac{1}{3}c_L + \alpha\frac{1}{3}c_H$$
$$\mathrm{E}(U_s|s_{i,c_H}) = \mathrm{E}(U_s|s_{j,c_H})$$

The supervisor is indifferent between the two ideas and will thus randomly select one idea.

$$D(c) = (c_i, c_j)\ with\ \left(\frac{1}{2}, \frac{1}{2}\right)$$

Now, let us look at the worker's choice of behaviour. If the worker is assigned high creative ability, he does not decide on an effort level; in the current setting, effort exertion is impossible for this type of worker. Thus, the strategy set of both players are the same: when they are assigned low ability, they decide to exert effort or not to exert effort. When given high creative ability, no effort decision takes place. For the sake of analysis, I represent the strategy set of the 'opponent' of worker i, worker j, in Table 1.a. When worker i applies strategy $K(e)$, he does not exert effort when assigned any level of creative ability. If he decides to apply strategy $L(e)$, he will decide to exert effort when he is attributed low creative ability.

		$\boldsymbol{c_H}$
		$e = 0$
$\boldsymbol{c_L}$	$e = 0$	$K(e) = \begin{cases} c_L, & e = 0 \\ c_H, & e = 0 \end{cases}$
	$e = 1$	$L(e) = \begin{cases} c_L, & e = 1 \\ c_H, & e = 0 \end{cases}$

Table 1.a: strategy set, when effort can only be exerted by low-ability workers

To detect any stable equilibrium in which either, neither or both workers exert effort, I computed the effort conditions for worker i with low creative ability. The effort condition (EC) compares the utility gains from deciding to exert or not to exert effort, for a single ability level and strategy of the opponent. The condition thus describes when it is optimal to exert effort, for the specific circumstances. Full calculations are represented in Appendix I, Table 2.a shows the effort condition for worker i, when faced with the opponent's strategy K(e) or L(e).

	Facing strategy K(e) of player j	Facing strategy L(e) of player j
$\boldsymbol{c_L}$	$\left(-\frac{1}{2}\alpha p\right)\left(\frac{1}{3}\ c_H - \frac{1}{3}\ c_L\right) > \theta$	$\left(-\frac{1}{2}\alpha p\right)\left(\frac{1}{3}\ c_H - \frac{1}{3}c_L\right) >\ \theta$

Table 2.a: effort conditions in the basic model

The first effort condition applies when worker i is given low creative ability and facing strategy K(e) by his opponent. The partial conclusion from this equation is rather obvious: the effort condition does not hold true for any legit value of the variables. By definition, some proportion of the population has high creative ability, the odds of successful communication are positive, the payoff of a highly creative idea is higher than the payoff of a low creative idea and the cost of effort are positive; $\alpha > 0, p \geq 0, \left(\frac{1}{3}\ c_H - \frac{1}{3}c_L\right) > 0$ and $\theta > 0$. Thus, it is irrational for worker I with low creative ability to exert effort under any circumstance, if worker j applies strategy K(e). This same argument holds when low ability worker i is faced with strategy set L(e) of the opponent. By definition, the effort condition does not hold. Thus, it is irrational for worker I with low creative ability to exert effort, if worker j applies strategy L(e).

Regardless of the strategy his opponent choses, worker i will decide not to exert effort in this setting. Thus, not exerting effort is his dominant strategy. Incentives for both workers are symmetric, therefore the same argument holds for worker j; given any creative ability level, neither worker exerts effort to signal. No worker can increase their utility by changing their course of action. The supervisor is able to select the best idea, given the received signals. Thus, a single symmetric equilibrium in pure strategies can be established.

$$\left(K_i(s), K_j(s), \mathrm{D(c)} = \begin{cases} c_i, & c_i > c_j \\ c_j, & c_i < c_j \\ c_i, c_j, \text{with } \left(\frac{1}{2}, \frac{1}{2}\right), & c_i = c_j \end{cases} \right)$$

In the basic setting, neither worker wants to put effort into sending a high ability signal. Intuitively, the argument is quite clear; increased effort is costly and forging his idea through successful signalling can even sabotage his own project payoff - if he achieves implementation of his bad idea in randomization over his opponent's good idea. When neither worker puts effort into signalling, the best idea is chosen, and all actors gain the highest possible utility.

Backward induction clarified that the supervisor will select the idea c_n with the highest potential payoff R_n. Workers are aware that if they engage in signalling, they might disrupt this efficient process and risk forgoing a higher payoff, if their co-workers idea is of superior quality. Thus, workers will not attempt to manipulate the implementation process through investing effort in signalling. All interests are perfectly aligned; it is optimal for each actor to work on the idea with the highest revenue. Without reputational concerns, the implementation process is efficient.

The next section will introduce reputational concerns into the model; will the single equilibrium remain stable? Will new equilibria arise?

3.2 The basic model; introducing reputation

Where some models include monetary compensation in implementation models for individual behaviour (i.e. Rotemberg & Saloner, 2000), reputation may have similar consequences. From the literature, the benefits of reputation are clear. Both instrumental and affective support are valuable to the progression of one's career, and make this journey a more pleasant one. In my setting, the benefits of reputation are induced by the signal of your idea being chosen, displaying supposed high creative ability. The reputational benefits are summarized in a single utility gain (B_i). Incentives are thus induced by monetary payoff as well as reputation increases. How will effort allocations of the workers change? The formal changes to the model are presented in the following section.

Looking at the original utility function of the workers, the only alteration occurs in *B*. If worker i's idea is implemented, $\mathrm{I}_i = 1$, positive utility can be attained through B_i. B_i is assumed to take the same value for all workers, regardless of creative ability or individual preferences for reputation.

$$U_i = \frac{1}{3}R + I_i B_i - \theta e_i$$
$$B_i = B_j > 0$$

Now, misalignment of incentives occurs; if payoffs of the ideas are equal, workers are no longer indifferent between working on either idea. Both workers will weigh the cost of effort against the additional utility of own idea implementation (OII) and the consequences for the payoff level of the implemented project. As the structure of the game remains unchanged, the extended form of this game is also represented by Figure 1.a.

3.2.1 Solving the basic model; introducing reputation

What are the consequences for the stable equilibrium that was established in the basic setting, where reputational concerns played no role? Given the strategy set of the co-worker, is restricting effort still the utility-maximizing option, for each ability level? The supervisor is by definition not concerned about his reputation, thus the analysis of his optimal decisions holds throughout the analysis. To establish new equilibria in this game with reputational concerns, this section compares the utility levels that are attained through each action, given the possible strategies of the co-worker.

As stated before, the model consists of symmetric incentives only, so choosing either perspective makes no difference for the analysis. To check for a pure Nash equilibrium, the optimal behavioural strategy for worker i will be discussed, given the behaviour of worker j in equilibrium. To assess the optimal strategy for worker i facing each strategy, I analysed the utility gains for both effort exertion and non-effort exertion for each of the strategies of the opponent. The resulting effort conditions again show when it is optimal for a worker to exert effort, given the circumstances. The effort conditions are represented in Table 2.b. Calculations are provided in Appendix II.

EC	Facing strategy K(e) of player j	Facing strategy L(e) of player j
u_{i,c_L}	$\left(\frac{1}{2}p\right) I_i\, B_i > \theta e_i + \frac{1}{2}\alpha p\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$	$\left(\frac{1}{2}p\right) B_i > \theta + \frac{1}{2}\alpha p\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$

Table 2.b: effort conditions in the basic model with reputational concerns

Results show that a low ability worker decides to exert effort when facing either strategy K(e) or L(e), case 1.a and case 2.a, if the above effort conditions are fulfilled. The positive utility of reputational gains has to exceed combined negative utilities from effort and possible foregone utility from a high ability idea, in order for the worker to choose to invest effort into signalling. The first coefficient term, in front of B_i, reflects a change in odds of own idea implementation (OII). The coefficient of $\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$ reflects a potential change in odds of missing out on a high quality idea. The effort conditions (EC) show that, for these cases, a high p increases the odds of reputational gains from implementation, when effort is invested in signaling: simultaneously, successful misguiding signalling increases and more sub-optimal ideas are implemented. Thus, an increase in p has two aspects: though it raises the odds of a utility gain from reputation, the odds of missing out on a potential high creative ability idea of the coworker also increase. Parameter α does not affect the incremental change in odds of reputational gains that arises from effort exertion; worker i's fate is dependent on parameter p. A higher level of α does put worker i at higher risk of forging his inferior idea over his co-worker's better idea.

To establish a symmetric equilibrium in pure strategies, the behaviour of worker i is considered, given the strategy set chosen by worker j. If such an equilibrium occurs in case 1.a, worker i mimics worker j's behaviour and thus not exert effort; if worker j chooses strategy set K(e), deciding to not exert effort if attributed with low creative ability, it is optimal for worker i with low ability to also not exert effort, if

$$B_i \leq \frac{2\theta}{p} + \alpha\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$$

Naturally, reputational concerns encourage signalling behaviour and thus discourage mimicking, in this particular case. A high α raises the cost potential forgone payoffs, encouraging to refrain from signalling attempts. The parameter p reflects a trade-off, its role is determined by the relative sizes of

B_i and $\left(\frac{1}{3}\ c_H - \frac{1}{3}\ c_L\right)$. If the effort condition for case 1.a holds, neither worker invests efforts into signalling. Thus, the following symmetric equilibrium in pure strategies occurs.

$$\left(\left(K_i(e), K_j(e), D(c) = \begin{cases} c_i, & c_i > c_j \\ c_j, & c_i < c_j \\ c_i, c_j, \text{with } \left(\frac{1}{2}, \frac{1}{2}\right), & c_i = c_j \end{cases}\right) \middle| B_i \leq \frac{2\theta}{p} + \alpha\left(\frac{1}{3}\ c_H - \frac{1}{3}\ c_L\right)\right)$$

In case 1.b, worker j chooses strategy set L(e), exerting effort when attributed with low creative ability. It is then optimal for worker i to mimic worker j's strategy, if:

$$B_i > \frac{2\theta}{p} + \alpha\left(\frac{1}{3}\ c_H - \frac{1}{3}\ c_L\right)$$

This is the inverted version of the mimicking condition for case 1.a, altered to illustrate mimicking behaviour for a different strategy by worker j. A higher α discourages mimicking behaviour by increasing the odds of forgoing a higher payoff. The higher parameter p, the lower the relative cost of effort, encouraging worker i to choose strategy set L(e) as well. A second potential symmetric equilibrium in pure strategies occurs, if:

$$\left(\left(L_i(e), L_j(e), D(c) = \begin{cases} c_i, & c_i > c_j \\ c_j, & c_i < c_j \\ c_i, c_j, \text{with } \left(\frac{1}{2}, \frac{1}{2}\right), & c_i = c_j \end{cases}\right) \middle| B_i > \frac{2\theta}{p} + \alpha\left(\frac{1}{3}\ c_H - \frac{1}{3}\ c_L\right)\right)$$

In general, what can be learnt from these equilibria? In the first equilibrium, involving symmetric strategy K(e), both workers refrain from adverse signalling behaviour in an attempt to forge their idea to be implemented. This is the efficient equilibrium; the best idea is implemented and neither worker incurs void signalling costs. In equilibrium L(e), workers do invest in signalling, reducing overall surplus by effort costs. Hence, this equilibrium is not efficient. Both equilibria are mutually exclusive; both equilibria cannot occur in a single set of parameter values. High benefits to reputation (B) and high odds of signalling success (p) contribute to the occurrence of equilibrium L(e), while impeding the event of equilibrium K(e) occurring. A high proportion of creative workers (α) as well as a high incremental payoff of the superior idea $\left(\frac{1}{3}\ c_H - \frac{1}{3}\ c_L\right)$ contribute to the occurrence of equilibrium K(e) over equilibrium L(e). Consequently, high benefits to reputation and high odds of success in signalling may divert the equilibrium from efficiency, equilibrium K(e), to the inefficient outcome of workers engaging in signalling, equilibrium L(e).

3.3 Model extension: when signalling is anyone's game

Realistically, high ability workers have similar individual reputational concerns. Thus, this type of workers may decide to exert effort to signal their high ability, achieve idea selection and gain utility from an increase in reputation. In figure 1.b, I introduce a new strategy: $(c_H, e = 1)$. With this strategy, high creative ability workers can unambiguously signal their creative ability through signal s_{H^+}.

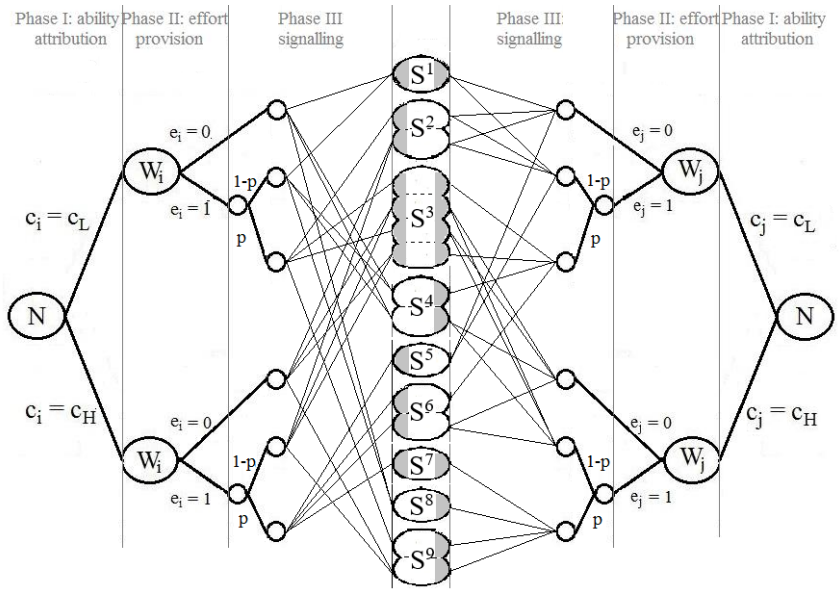

Figure 1.b: game tree of the extended game

Supervisors can now verify high creative ability. Nevertheless, this is costly for the worker. θ is assumed to be equal for effort of low and highly creative workers.

$$\theta_{i,c_L} = \theta_{i,c_H} = \theta_{j,c_L} = \theta_{j,c_H}$$

This new strategy adds 5 new scenarios of signal combinations to the game tree, as presented through the bolder lines in Figure 1.b. Supervisors can receive a set of any combination of the three possible signals, $s = (s_L, s_H, s_{H^+})$, which are constructed as follows.

$$s = \begin{cases} s_L, & if\, c = c_L and\, e = 0 \\ s_H, & if\, c = c_H and\, e = 0, or\, if\, c = c_L\, and\, e = 1 \\ s_{H^+}, & if\, c = c_H\, and\, e = 1 \end{cases}$$

Signals s_L and s_{H^+} are fully informative of the creative ability of the workers. The signal of high creative ability is not fully informative: both creative ability types can provide such a signal. Workers thus have the option to ensure that their high ability is observed by putting effort into signalling.

To allow for signalling behaviour of high ability workers, two additional possible strategies arise for worker j; M(e) & N(e). The composition of strategy sets are represented in Table 1.b. Illustratively, when worker j chooses strategy set M(e), he only puts effort into signalling when he is attributed high creative ability.

		c_H	
		$e = 0$	$e = 1$
c_L	$e = 0$	$K(s) = \begin{cases} c_L, & e = 0 \\ c_H, & e = 0 \end{cases}$	$M(s) = \begin{cases} c_L, & e = 0 \\ c_H, & e = 1 \end{cases}$
	$e = 1$	$L(s) = \begin{cases} c_L, & e = 1 \\ c_H, & e = 0 \end{cases}$	$N(s) = \begin{cases} c_L, & e = 1 \\ c_H, & e = 1 \end{cases}$

Table 1.b: strategy set, when effort can be exerted by all types of workers

Section 3.3.1 covers the different scenarios that can occur, using backward induction in the analysis; first, the supervisor's implementation decisions is considered, then the game is analysed from the workers point of view.

3.3.1 Solving the extended model

The supervisor's strategy set is represented in presented in Figure 1.b. For example, in the first scenario, the supervisor receives low ability signals from both workers. Thus, he will randomly select one idea for implementation. In the second scenario, the supervisor receives a diverse set of signals: $(s_{i,H}, s_{j,L})$. The supervisor decides to implement the idea of worker i. The supervisor's decision rule is represented by the grey areas in Figure 1.b. Calculations are provided in Appendix III.

To find new equilibria, the effort allocation decision of worker i will be analysed, considering their co-workers strategy options. Since worker i now also has the option to exert effort when ability is high, case 1 and 2 are reconsidered. Then, case 3 and 4 are analysed, for worker i attributed with low or high creative ability. The new effort exertion rules are represented in Figure 2.c.

EC	Facing strategy K(e) of player j	Facing strategy L(e) of player j	Facing strategy M(e) of player j	Facing strategy N(e) of player j
u_{i,c_L}	$\left(\frac{1}{2}p\right) I_i\, B_i > \theta e_i + \frac{1}{2}\alpha p\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$	$\left(\frac{1}{2}p\right) B_i > \theta + \frac{1}{2}\alpha p\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$	$\left(\frac{1}{2}p(1-\alpha p)\right) B_i > \theta + \left(\frac{1}{2}\alpha p(1-p)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)$	$\left(\frac{1}{2}p(1-\alpha p)\right) B_i > \theta + \left(\frac{1}{2}\alpha p(1-p)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)$
u_{i,c_H}	$\frac{1}{2}\alpha p B_i > \theta$	$\frac{1}{2}pB_i - \left((\alpha - 1)\frac{1}{2}p\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right) > \theta$	$\frac{1}{2}\alpha p B_i > \theta$	$\frac{1}{2}p(p-\alpha p+\alpha)B_i - \left((\alpha - 1)\frac{1}{2}p^2\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right) > \theta$

Table 2.c: effort exertion - decision rules

In case 1.b, worker i faces strategy K(e) from his co-worker; he decides to attempt to signal if the following EC is fulfilled.

$$\frac{1}{2}\alpha p B_i > \theta$$

In this case, 1.b, successful signalling guarantees implementation. A higher α implies that the odds of a co-worker to be the high ability type increase. In this case, effort exertion is more valuable when these odds are high; only when the co-worker is high ability, successful signalling comes increases the odds of idea implementation. The EC is also more likely met as p increases: the higher p, the odds of successful signalling and implementation increase. As worker j does not exert effort, he does not benefit from higher values of p. In the event of being attributed with high creative ability, the worker is no longer at risk of forcing his idea over a possible more rewarding idea of a co-worker. Instead, the worker can achieve higher utility through ensuring implementation of a highly creative idea, given that signalling is successful. In case 1.b, this trade-off of effort cost and 'guaranteed' high payoff is no concern, since worker i is not at risk of implementation of a low quality idea, given worker j's strategy. Thus, the effort condition only depends on the cost of effort and value of reputation gains.

In the extended model of reputational concerns, the equilibrium condition for a symmetric equilibrium in pure strategies is slightly more complicated. In basic model with reputational concerns, an equilibrium was established when worker i mimicked worker j's effort decision, given low creative ability of worker i. In this section, such an equilibrium can only be established if worker i mimics behaviour when attributed either creative ability level.

Case 1. If worker j does never exert effort (strategy set K(e)),

a) And worker i is attributed low creative ability, the effort condition is the same as in the previous section; it is optimal for him to also not exert effort if,

$$B_i \leq \frac{2\theta}{p} + \alpha\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$$

b) If worker i has high creative ability, it is optimal for worker i to abstain from signalling, if

$$B_i \leq \frac{2\theta}{\alpha p}$$

The higher the cost of effort and the lower odds of successful signalling and reputational gains, the more likely the equilibrium is reached. Again, for a symmetric equilibrium in pure strategies, both conditions must be fulfilled; essentially, if the costs of effort, relative to model conditions (α, p), are too high, or (combined with) the potential of forgoing a better idea is too costly, the following equilibrium may occur. The first symmetric equilibrium in pure strategies is characterized as follows.

$$\left(\left(K_i(e), K_j(e), D(c) = \begin{cases} c_i, & c_i > c_j \\ c_j, & c_i < c_j \\ c_i, c_j, \text{with } \left(\frac{1}{2}, \frac{1}{2}\right), & c_i = c_j \end{cases} \right) \middle| B_i \leq \begin{pmatrix} \frac{2\theta}{p} + \alpha\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right) \\ \frac{2\theta}{\alpha p} \end{pmatrix} \right)$$

In case 2.b, worker i is again attributed high creative ability and faced with strategy L(e): worker j exerts effort only when attributed low ability.

$$\frac{1}{2} p B_i + \left(\frac{1}{2} p - \frac{1}{2} \alpha p\right)\left(\frac{1}{3} c_H - \frac{1}{3} c_L\right) > \theta$$

The odds of reputational gains increase as p increases; more successful signalling is beneficial to worker i. Interestingly, the parameter α does not affect the odds of reputational gain. The coefficient of the second parameter shows that the higher the chances of successful signalling, the higher the odds of superior idea implementation. This effect is dampened by α: as α increases, the positive impact of p diminishes. As the population becomes more and more creative, signalling becomes less important for implementation of highly creative ideas: the chances of both ideas being highly creative grow. To establish a potential equilibrium, the effort conditions for worker i when attributed low and high creative ability are jointly considered.

Case 2. If worker j applies strategy set L(e) and exerts effort only if attributed with low creative ability,

a) And worker i is attributed with low creative ability, again the effort condition from the previous section holds; it is optimal for him to mimic worker j's strategy if;

$$B_i > \frac{2\theta}{p} + \alpha\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$$

b) If worker i is attributed with high ability, it is optimal to copy worker j's strategy and not exert effort, if:

$$B_i - (\alpha - 1)\left(\frac{1}{3} c_H - \frac{1}{3} c_L\right) \leq \frac{2\theta}{p}$$

Here, the issue becomes more complicated. High reputational gains contribute to a possible equilibrium in case 1.a, while compromising case 1.b; the inverse relation holds for cost of potential foregone payoffs. The equilibrium is only viable if both conditions hold, and thus,

$$(\alpha - 1)\left(\frac{1}{3} c_H - \frac{1}{3} c_L\right) > \alpha\left(\frac{1}{3}\, c_H - \frac{1}{3}\, c_L\right)$$

No set of parameter values fulfils this condition; hence the equilibrium is not feasible for either worker. The strategy set L(e), within the specifications of this extended model, cannot be part of a symmetric equilibrium in pure strategies.

In case 3, worker j has chosen strategy set M(e); he exerts effort only when he is attributed high creative ability. Low creative ability worker i exerts effort only if the following EC is fulfilled.

$$\left(-\frac{1}{2}\alpha p^2+\frac{1}{2}p\right)B_i > \theta+\left(\frac{1}{2}\alpha p\,(1-p)\right)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)$$

Odds of OII unambiguously decrease as α increases; worker j reveals his high creative ability when he is attributed as such, and can ensure implementation through successful signalling, given worker i's low creativity. On the other end of the EC, a higher α increases the odds of suboptimal idea implementation, resulting in costs. An increase in p suggests higher odds of implementation of the own idea, though this also holds for worker j; the increase is dimmed by a higher α. Mutual successful signalling will result in implementation loss against a high ability co-worker. Thus, this dimming effect increases as α increases. On the other hand, from section 3.1 and 3.2, it became clear that signalling can be costly when attributed with low ability: the worker may miss out on a more rewarding idea. A higher α increases these odds. The odds of this occasion are highest when $p=\frac{1}{2}$. Both higher and lower values of p decrease the odds: either both signals are successful, or both signals fail, in which case the best idea is implemented.

When worker i is attributed high ability and faced with strategy set M(e) , his effort exertion rule coincides with the effort rule of case 1.b: $\frac{1}{2}\alpha p B_i > \theta$. The difference between case 1.b and 3.b lies in the effort strategies of worker j, K(e) and M(e). The fact that in strategy set M(e) worker j exerts effort in high creative ability does not alter the effort trade-off of worker i. Increases in both α and p make it more attractive for worker i to invest in effort. Again, since worker j does not exert effort when attributed with low creative ability, worker i does not have to consider effort exertion to ensure the implementation of a high payoff idea; OII is guaranteed. In this case, can strategy M(e) be a part of a symmetric equilibrium?

Case 3. In this case, if worker j exerts effort only when attributed with high ability, applying strategy set M(e),

a) It is optimal for worker i with low creative ability to also abstain from signalling efforts if

$$B_i \le \frac{2\theta}{(-\alpha p^2+p)}+\frac{\left(\alpha(1-p)\right)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)}{(1-\alpha p)}$$

b) If worker i is attributed high creative ability, it is optimal to exert effort if

$$B_i-(\alpha-1)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)>\frac{2\theta}{p}$$

The symmetric equilibrium occurs only if both conditions are fulfilled in a single set of parameters;

$$\frac{2\theta}{(-\alpha p^2+p)}+\frac{\left(\alpha\,(1-p)\right)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)}{(1-\alpha p)} \ge B_i > \frac{2\theta}{p}+(\alpha-1)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)$$

For a moment ignoring the parameter value of B, is the occurrence of such a scenario possible within the boundaries of the model? The two conditions jointly require that the following condition holds:

$$\frac{2\alpha p\theta}{p(1-\alpha p)}>(\alpha-1)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)+\frac{-\left(\alpha\,(1-p)\right)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)}{(1-\alpha p)}$$

The first term is positive for any set of values, while the second and third terms are negative for all possible parameter values. Hence, the condition holds for any set of parameter values of $(\alpha, p, \theta, c_L, c_H,)$. The implication of this finding is not that both conditions hold for all parameter values; this equation implies that equilibrium M(e) may occur, given that the benefit to reputation falls into the range conditioned by both mimicking conditions. This equilibrium in pure strategies, in which both workers choose strategy set M(e), can be characterized as follows.

$$\left(\left(M_i(e), M_j(e), D(c) = \begin{cases} c_i, & c_i > c_j \\ c_j, & c_i < c_j \\ c_i, c_j, \left(\frac{1}{2}, \frac{1}{2}\right) & c_i = c_j \end{cases}\right) \middle| \frac{2\theta}{(-\alpha p^2 + p)} + \frac{\big(\alpha(1-p)\big)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)}{(1-\alpha p)} \geq B_i > \frac{2\theta}{p} + (\alpha - 1)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)\right)$$

In case 4, worker j applies strategy set N(e): he always exerts effort, no matter his ability level. The EC for case 4.a is the same as for case 3.a. For worker i with low creative ability, effort exertion has the same consequences for reputational gains and incremental project payoff, given opponent j's strategy M(e) or N(e).

$$\left(-\frac{1}{2}\alpha p^2 + \frac{1}{2}p\right)B_i > \theta + \left(\frac{1}{2}\alpha p(1-p)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)$$

A high p increases the (net) odds of reputational gain and reduces the odds of sub-optimal implementation; for the latter, a low parameter value for p works the same way. A high value of α hinders this condition by reducing the odds of reputational gain and facilitating implementation of a project with inferior payoff value.

In case 4.b, worker i of high creative ability is faced with strategy set N(e): worker j exerts effort given either ability level. Worker i's effort condition is presented below.

$$\frac{1}{2}p(p - \alpha p + \alpha)B_i - \left(\frac{1}{2}p^2(\alpha - 1)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right) > \theta$$

An increase in p encourages signalling behaviour through increased odds of reputation gain, though this is dampened by α; the higher the proportion of α, the less likely effort will ensure OII. The net effect of α depends on the value of parameter p; the highest odds of implementation occur when p is high and α is low; worker i can successfully communicate his high ability and win the competition for OII. The worker again can increase the odds of implementation of a high payoff idea through exerting effort. The higher p, the higher the chances are of implementation of a highly creative idea. The same dimming effect of α occurs as for case 2.b. As chances of the production of two creative ideas increase, signalling becomes less rewarding.

Case 4.a Can strategy set N(e) be part of a symmetric equilibrium in pure strategies? If worker i faces strategy set N(e) by opponent j,

a) and he is attributed with low creative ability, he will exert effort if,

$$B_i > \frac{2\theta}{(p(1-\alpha p))} + \frac{\big(\alpha(1-p)\big)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)}{(1-\alpha p)}$$

b) if worker i is attributed with high creative ability, he will exert effort if,

$$B_i > \frac{2\theta}{p(p - \alpha p + \alpha)} + \frac{\big(p(\alpha - 1)\big)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)}{(p - \alpha p + \alpha)}$$

Given that the parameter values fulfil both conditions, the following equilibrium will arise:

$$\left(\left(N_i(e), N_j(e), D(c) = \begin{cases} c_i, & c_i > c_j \\ c_j, & c_i < c_j \\ c_i, c_j, \left(\frac{1}{2}, \frac{1}{2}\right) & c_i = c_j \end{cases} \right) \middle| B_i > \begin{matrix} \frac{2\theta}{(p(1-\alpha p))} + \frac{\left(\alpha(1-p)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)}{(1-\alpha p)} \\ \frac{2\theta}{p(p-\alpha p+\alpha)} + \frac{\left(p(\alpha-1)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)}{(p-\alpha p+\alpha)} \end{matrix} \right)$$

Can these three, or even one set of equilibria arise under a single set of conditions, implying that the model contains multiple equilibria? First, a dual symmetric equilibrium with strategy sets K(e) and M(e) are considered. For equilibria 1 and 2 to coexist, both equilibrium conditions must be fulfilled in a single parameter set. The first three sub-conditions require reputational gains to be sufficiently small to compensate for relative effort cost and (except for case 1.b) the risk of forgone payoffs. In case 2.b, where worker i is attributed high ability, this risk turns into a potential benefit by 'ensuring' a high payoff project. Thus, equilibrium 1 and 2 can occur in a single model specification. For equilibria 1 and 3 to co-occur, 'their' equilibria conditions must be fulfilled. These conditions are quite strained, requiring reputational gains to be lower than a certain threshold and higher than a different threshold, both highly correlated. Hence, these two equilibria do not occur in the model jointly. A more specific explanation is provided in Appendix IV. The last possibility for multiple equilibria involves equilibria 2 and 3. The effort conditions 3.a and 4.a are equal, while the condition for mimicking behaviour in equilibrium is its inverse. Thus, equilibrium 2 (strategy set M(e)) and 3(strategy set N(e)) do not co-occur in a single parameter set for the model.

Concluding, the model allows for three symmetric equilibria in pure strategies, encompassing strategy sets in which both workers never exert effort (K(e)), allocate effort only when attributed high creative ability (M(e)), or decide to exert effort given any ability level (N(e)). Only the first two equilibria can occur in a single set of parameter values.

4 Discussion

The question that is at the base of this research is: how can organisations invest in the most rewarding innovations? Much research is done on the topic of (organisational) innovation, establishing factors that are associated with high innovation output, conditions for a stimulating environment, and personality factors that are related to highly creative output. The majority of this research ignores or underemphasizes the role of micro-processes in the innovational process and, more specifically, motivational antecedents of employees' innovative behaviour. This research focuses specifically on a single motivational antecedent: reputation. Starting from a model without reputational concerns present, efficiency is achieved; workers do not put effort toward signalling, and the supervisor can make the optimal implementation decision. The role of reputational gains from innovation is illustrated in a model of individual innovative behaviour, providing testable hypotheses for future research. The first hypothesis states that, if the gains of reputation are zero, no worker will invest effort into signalling. The second hypothesis states that if the benefits to reputational gain are sufficiently high, it can be optimal for a worker to invest in signalling. These parameter values differ across levels of signalling success rate, personal creative ability, the ratio of high and low creative workers in the market and the opponent's strategies. Thus, a range of equilibria may exist, in which a worker disturbs the efficient process of innovation implementation due to utility gains arising from reputational value.

The above stated hypotheses resonate well with existing research on reputational concerns and their results for individual behaviour. From section 1, it became clear that workers engage in innovative behaviour if they expect the outcome to be positive, in terms of performance and reputation. Innovative behaviour is believed to result in image gains, higher work quality, increased

productivity, a lower error rate, and improved general job performance (Cingöz & Akdoğan, 2011). The reversed relation is somewhat more difficult; evidence for reputation affecting innovative behaviour is hard to come by (e.g. Yuan & Woodman, 2010). Zinko, Gentry & Laird (2016) describe the mechanism behind reputational concerns: a threat to any reputational dimension induces concerns for reputation and affects behaviour. The hypotheses that are derived from the extended model with reputational concerns provide possibilities for testing this mechanism, in which reputational concerns possibly induce non-efficient behaviour, when provided with the 'right' set of parameter values. Future research must verify the consequences of reputational concerns for innovative behaviour. This research attempts to bridge (part of) the gap between theoretical statements and real world behaviour.

The analysis provided some general patterns for when a worker may exert effort to lie about the potential payoff of his idea to his supervisor. For low ability workers, a higher proportion of high creative ability workers discourages effort exertion. These workers risk missing out on a higher pay-off by putting effort toward signalling; this risk increases as the proportion of highly creative workers increases. Also, the higher this proportion, the lower the odds of effort exertion resulting in implementation of the worker's idea. Higher offs of successful signalling increase the odds of reputational gains as well as forgone payoffs. For high ability workers, signalling provides the opportunity to (almost) ensure implementation of a high payoff idea, if his opponent is gifted with low creative ability. Higher odds of signalling success encourage highly creative workers to exert effort; implementation in no case results in a low payoff. Diving somewhat deeper into the results, the main hypothesis was confirmed: reputational gains may disturb the efficient implementation process that is established in the absence of reputational concerns. In the restricted model, only workers with low creative ability can attempt signalling. Two symmetric equilibria may arise: both workers abstain from signalling, or both workers invest efforts into manipulation of their project payoff. The former arises when reputational gains are small and odds of successful signalling are low; the latter arises when a worker benefits greatly from reputational gains and signalling success is more likely. In the extended model, workers with high creative ability can also decide to signal. When a worker gives out this superior signal, if successful, it ensures implementation of a highly creative idea; though not necessarily the idea generated by this individual. In this model, the symmetric equilibrium in pure strategies in which both workers refrain from investing effort in signalling, no matter their level of creative ability, persists. Again, this equilibrium arises when gains of reputation and odds of successful signalling are low. In the second equilibrium, both workers exert effort only when attributed with high creative ability. This equilibrium only occurs for a limited range of values for reputational gains; reputational gains must be high enough to stimulate workers with high ability to engage in signalling, while not exceeding combined effort cost and potential forgone payoffs for workers with low creative ability. The final equilibrium is characterized by symmetric effort exertion for both ability types; workers invest in signalling irrespective of their opponent's strategy or own project payoff. This equilibrium occurs when reputational gains are large enough to compensate for effort cost as well as potential forgone payoffs for workers with low creative ability. The second equilibrium from the restricted model does not maintain itself in the extended model. If benefits of reputation are large enough to compensate the less creative workers for incurred costs, effort and forgone payoffs, it cannot be optimal to refrain from effort for workers with high creative ability; their gains from signalling behaviour are potentially larger. Concluding, substantial benefits to reputation may disturb the efficient process of idea implementation. The less creative workers may decide to attempt manipulation of their supervisor, to achieve implementation and reap the associated benefits. Moreover, highly creative workers may also engage in such adverse behaviour, when given the opportunity. Gains to idea implementation are even larger, since they are not at risk of forcing an inferior idea to be implemented.

Similar research on reputational concerns is rather scarce. Some are somewhat similar in terms of the research model and setup, although their interpretation of reputational utility gains is different. One of these researches is done by Li, Rantakari & Yuang (2016); they introduce competition into an innovation model of cheap talk, searching for stable equilibria in varying conditions for communication between sender and receiver. Their research describes how signalling parties have personal interests that are only partially aligned to the receiver's interests. Thus, when a worker's own idea is implemented, he receives a private benefit on top of the payoff of the implemented project. This private payoff shows great similarities to the reputational benefits of implementation in this research. Li, Rantakari & Yuang (2016) describe the cost of exaggeration, the agent with a project payoff in a high interval has a lower probability of missing out on a more rewarding project, as opposed to an agent with a project that falls into a low payoff interval. Therefore, an agent with a high potential payoff faces lower cost of exaggeration and overstate payoff more in communication. Where this research assumes reputational concerns to be at the base of signalling behaviour, Li, Rantakari & Yuang (2016) assume the personal project biases to determine the extent of project payoff exaggeration. Their model allows for many more than just two or three types of signals, enriching the analysis. The authors then discuss how the supervisor should take into account the sizes of these personal biases in dividing types of signals. It remains rather vague how the decision maker can allocate these options. Nevertheless, the authors provide a good illustration of the difficulties, or inefficiencies, that arise from workers' private biases. The model as described in my research is somewhat more simplified in specifying differential signals, though more comprehensive; the present model includes effort cost and leaves much room for specifications and extensions of reputational incentives. (Empirically tested) hypotheses provide more opportunities for applying it to real business settings in the future.

Another research that considers alternative incentives in individual innovative behaviour is executed by Rotemberg & Saloner (2000). While focussing on the benefits of a visionary CEO for innovation, the authors propose that firms can enhance innovative behaviour by providing exogenous rewards (through observable implementation) or endogenous incentive payments when a worker's idea is implemented. Rewarding workers' innovational efforts through publicizing implementation and a (small) wage increase to match to a worker's 'market value' may be an attractive option to the firm, if high incentive payments are not an option due to financial constraints. The exogenous type of reward resembles some form of reputation gain: a worker's perceived value increases in the eyes of the public. This research considers the stimulating effect of incentivizing innovation, but it ignores potential influencing cost, and how implementation is achieved in the first place. The here presented analysis adds to this how the implementation process may come at certain costs, as well as different types of rewards, each having different consequences for innovative behaviour.

While reputational gains from implementation may act as a stimulant for innovation efforts, this is only part of the story. The model discussion so far does not specify that the worker that does not achieve implementation of his idea experiences a reputation loss. Following Carter, Bitting & Ghorbani (2002), (professional) reputation is determined by to what extent the supervisor and co-workers believe the worker to have fulfilled the expectations. Thus, reputational gains must be regarded as gains relative to losing the battle for implementation. Additionally, gains to reputation are thus relative to the reputation of the opponent; reputation loss only occurs when the opponent's reputation for innovation is comparatively worse. This has many implications for the benefits of successful signalling. Workers with a high reputation for innovation have more 'to lose'. It is easier for workers with a bad reputation to exceed expectations and gain in reputation, and additionally, the risk of reputation loss is considerably lower. With that said, it may be easier to lose a good reputation than to gain one. (Yaniv & Kleinberger, 2000) Thus, extensive research must be done on this type of relations, before altering and enriching the model accordingly. Another aspect of reputation that has

yet remained unexposed is the potential downsides to idea implementation and reputation gain. For example, workers may experience additional pressure on performance resulting from a reputation gain, which sets a number of reactions in motion, on psychological, cognitive, emotional and social levels. (Driskell & Salas, 2013) It is thus difficult to specify the effect of a reputation gain for performance, or even the direction of this effect, but it is clear that a reputation gain has consequences beyond a unique utility increase. To include the two discussed facets of reputation, OII must be replaced with a parameter of relative performance; the reputational gain of OII must allow for positive as well as negative utility returns.

Limitations of this research do not arise from exterior constraints, since the model is theory-based. The model does hold some weaknesses, arising from the trade-off between practicality or applicability and comprehensiveness. Because the research is an orientation on the realistic process of implementation, the model focuses more on the former, leaving it up to future research to extend on its properties. This last section will discuss some of the model's weaknesses and potential research extensions. Though a large body of literature is discussed to attempt to capture the nature of the association between creativity, creative ability, idea quality and quantity, and innovation (revenue), the interrelations are too complex to capture in this specific model. Thus, this research neglects to identify and specify these associations in the model of innovation. From the literature, it is clear that creativity of the idea and internal creativity of the person are connected though not equivalents. Nevertheless, in the model I assume this to be the case. The focus of this research is the effect of reputational concerns on individual behaviour. A sound empirical incorporation is a valuable extension, though beyond the scope of this research. Another aspect that is so far neglected, but evidently important, is the aspect of risk in innovation. The model assumes all implementation attempts to be successful, though this is an unrealistic view (e.g. Dijksterhuis, 2016). Highly creative ideas often involve more risk, because implementation revenue takes extreme values; innovations involve ground-breaking changes and the revenues are through the roof, or the implementation is an absolute failure. Van de Ven (1986) expresses major concerns on how to make workers set aside their own concerns in terms of risk, as more innovative ideas generally carry more risk. He states that risk aversion extends to personal reputation; a worker may not publish his most innovative idea if he fears reputation loss. As discussed in the present section, with different reputations, the stakes are different for each worker.

The model also practices some obvious oversimplifications. First of all, workers are assumed to be attributed one of two possible creative ability levels. Realistically, creative ability has many, many aspects and covers a continuum of values. Also, creative ability does not coincide exactly with project payoff. In the absence of a signal, the supervisor is assumed to observe the true creative ability of the workers. Another important model restriction is the strategy set of the workers. It assumes each worker to invest in idea generation and development beforehand. As described by Van de Ven (1986), some workers may decide not to join this process entirely, if they estimate the costs to outweigh expected benefits. This simplification is only marginally relevant to this research; the effects on the mechanisms at work in the model are limited. Another simplification occurs in the signalling process. Workers choose to signal a single level-up creative ability/project payoff or not signal at all. In reality, workers have many more options for signalling. A worker may want to avoid working on their own innovation, for reasons of personal preference or potential embarrassment, and decide to signal slightly lower project payoffs. The boundary properties of the model must be altered to allow for this option.

A weakness, but simultaneous strength, of the model lies in the non-specificity of the parameters of the model. While the results only show general patterns, the room for interpretation and opportunities for future research to focus on a single one of those aspects are abundant. The results reveal a range of equilibria, occurring for different coefficients of the parameter values. Attributing and justifying numerical values of these parameters is difficult and these values are very specific to

each setting. For example, specifications of the incremental payoff of 'the better idea' vary across sectors, teams and especially per set of two matched workers; the proportion of highly-creative workers in the population is different for each firm; the odds of successful signalling depend on organisational structure, the supervisor's listening capabilities and, realistically, the worker's communication skills. Perceived cost of effort to send a disturbing signal differs across individuals (e.g. Van Bockstaele et al, 2012). An opportunity for future research lays in the current oversimplification of the absence of correlations between parameters. Benefits from reputation gain may differ across levels of creative ability. For example, low ability workers have more potential for improvement; they may profit more from the additional resources and social support. High ability workers may suffer from being perceived as arrogant, or a threat to co-workers' positions. Thus, gains to reputation may be greater for workers with a bad reputation. On the other hand, high ability workers may use their acclimation of resources to become even better at achieving successful implementations. The literature does not verify either argument. This research model may be used as a stepping stone to determine such differential reputational incentives.

The ultimate question of this research was as follows: how does reputation incentivize innovative behaviour? The results show that when reputational gains from implementation are sufficiently high, workers may exert effort to engage in signalling. Further research can shed more light on the challenges that firms face in implementation of innovations: firms should not assume that the interests of their employees for innovation are aligned with their own. Incentives from reputation may disturb the implementation process. To counteract this, firms must attempt to align these interests by creating an organisational environment in which reputation is not important. As discussed in section 2, reputation comes into action when it is the actors' most accurate source of information. Increased transparency and information sharing could thus reduce the importance of reputation. The organisation may also implement measures to decrease the odds of successful signalling; train supervisors to recognize creative ability and potential project payoff and formalize the information-sharing process. Ultimately, the development of an organisational strategy that ensures efficiency in the implementation process would have major benefits for the organisation.

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Appendix I: Solving the basic game

A1.1 The supervisor's implementation decision

Scenario 1

In the first scenario, the supervisor receives two signals of low creative ability.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_L}) = \frac{1}{3}c_L$$
$$\mathrm{E}(U_s|\mathrm{s}_{j,c_L}) = \frac{1}{3}c_L$$
$$\mathrm{E}(U_s|s_{i,c_L}) = \mathrm{E}(U_s|s_{j,c_L})$$

Thus, the supervisor is indifferent between choosing either idea and will randomly select one idea for implementation.

$$D(c) = (c_i, c_j)\ with\ \left(\frac{1}{2}, \frac{1}{2}\right)$$

Scenario 2

In scenario 2, the supervisor receives a high ability signal from worker I, while receiving a low ability signal from worker j.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H}) = (1-\alpha) * \frac{1}{3}c_L + \alpha * \frac{1}{3}c_H$$
$$\mathrm{E}(U_s|\mathrm{s}_{j,c_L}) = \frac{1}{3}c_L$$
$$E(U_s|\mathrm{s}_{i,c_H}) > \mathrm{E}(U_s|\mathrm{s}_{j,c_L})$$

Since $\alpha < 0$, the expected utility of worker I's idea is higher. Therefore, the supervisor will decide to implement the idea of worker i.

$$D(c) = c_i$$

Scenario 3

In the third scenario, the supervisor receives two signals of high creative ability. The expected utility levels for selecting and implementing either idea are as follows.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H}) = (1-\alpha)p\frac{1}{3}c_L + \alpha\frac{1}{3}c_H$$
$$\mathrm{E}(U_s|\mathrm{s}_{j,c_H}) = (1-\alpha)p\frac{1}{3}c_L + \alpha\frac{1}{3}c_H$$

Thus,

$$\mathrm{E}(U_s|s_{i,c_H}) = \mathrm{E}(U_s|s_{j,c_H})$$

The supervisor is indifferent between the two ideas and will thus randomly select one idea.

$$D(c) = (c_i, c_j)\ with\ \left(\frac{1}{2}, \frac{1}{2}\right)$$

Scenario 4

In scenario 4, the supervisor receives a high signal from worker j, and a low signal from worker i.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_L}) = \frac{1}{3}c_L$$
$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H}) = (1-\alpha) * \frac{1}{3}c_L + \alpha * \frac{1}{3}c_H$$
$$E(U_s|\mathrm{s}_{j,c_H}) > \mathrm{E}(U_s|\mathrm{s}_{i,c_L})$$

When faces with scenario 4, the supervisor will decide to implement the idea of worker j.

$$D(c) = c_j$$

A1.2 The workers' effort decision

The workers decision, when the worker is assigned low ability: to signal or not to signal? Two possible cases: worker i faces strategy K(e), case 1, or strategy L(e), case 2. As reputational concerns at this point are absent ($B = 0$), reputation is derived only from project payoff ($c_L\ or\ c_H$) and effort, through θ.

Case 1

If worker i with low ability faces strategy K(e), his utility gains from deciding to exert or not exert effort are as follows.

$$\mathrm{U}_{i,c_L,e=0|K(e)} = \alpha * U_{c_L,e=0,'lose'} + (1-\alpha)(U_{c_L,e=0,'tie'})$$

$$\mathrm{U}_{i,c_L,e=0|K(e)} = \alpha\frac{1}{3}\,c_H + (1-\alpha)\left(\frac{1}{2}*\frac{1}{3}\,c_L + \frac{1}{2}*\frac{1}{3}\,c_L\right)$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|K(e)} = {} & \alpha\left(p * U_{c_L,e=1'tie'} + (1-p)U_{c_L,e=1,'lose'}\right) \\ & + (1-\alpha)\left(p * U_{c_L,e=1'win'} + (1-p)U_{c_L,e=1'tie'}\right)\end{aligned}$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|K(e)} = {} & \alpha\left(p\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right) + \frac{1}{2}*\left(\frac{1}{3}\,c_H - \theta e_i\right)\right) + (1-p)\left(\frac{1}{3}\,c_H - \theta e_i\right)\right) \\ & + (1-\alpha)\left(p\left(\frac{1}{3}\,c_L - \theta e_i\right) + (1-p)\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right) + \frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right)\right)\right)\end{aligned}$$

He will exert effort if

$$\begin{aligned}& \alpha\left(p\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right) + \frac{1}{2}*\left(\frac{1}{3}\,c_H - \theta e_i\right)\right) + (1-p)\left(\frac{1}{3}\,c_H - \theta e_i\right)\right) \\ & \quad + (1-\alpha)\left(p\left(\frac{1}{3}\,c_L - \theta e_i\right) + (1-p)\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right) + \frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right)\right)\right) \\ & \quad > \alpha\frac{1}{3}\,c_H + (1-\alpha)\frac{1}{3}\,c_L\end{aligned}$$

$$\begin{aligned}& \alpha\left(p\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right) + \frac{1}{2}*\left(\frac{1}{3}\,c_H - \theta e_i\right)\right) + (1-p)\left(\frac{1}{3}\,c_H - \theta e_i\right)\right) \\ & \quad + (1-\alpha)\left(p\left(\frac{1}{3}\,c_L - \theta e_i\right) + (1-p)\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right) + \frac{1}{2}*\left(\frac{1}{3}\,c_L - \theta e_i\right)\right)\right) \\ & \quad > \alpha\frac{1}{3}\,c_H + (1-\alpha)\left(\frac{1}{3}\,c_L\right)\end{aligned}$$

$$\begin{aligned}& \left(\frac{1}{2}ap + (1-a)p + \frac{1}{2}(1-a)(1-p) + \frac{1}{2}(1-a)(1-p) - (1-a)\right)\frac{1}{3}\,c_L \\ & \quad + \left(\frac{1}{2}ap + a(1-p) - a\right)\frac{1}{3}\,c_H > \theta e_i\end{aligned}$$

$$\left(\frac{1}{2}ap\right)\frac{1}{3}\,c_L + \left(-\frac{1}{2}ap\right)\frac{1}{3}\,c_H > \theta e_i$$

Thus, worker i will exert effort when,

$$\left(-\frac{1}{2}ap\right)\left(\frac{1}{3}\,c_H - \frac{1}{3}\,c_L\right) > \theta e_i$$

Case 2

Low ability worker i is faced with strategy L(e), utility is derived as follows:

$$\mathrm{U}_{i,c_L,e=0|L(e)} = \alpha * U_{c_L,e=0,'lose'} + (1-\alpha)(pU_{c_L,e=0,'lose'} + (1-p)U_{c_L,e=0,'tie'})$$

$$\mathrm{U}_{i,c_L,e=0|L(e)} = \alpha * \frac{1}{3}\, c_H + (1-\alpha)\left(p * \frac{1}{3}\, c_L + (1-p)\left(\frac{1}{2}\left(\frac{1}{3}\, c_L\right) + \frac{1}{2} * \frac{1}{3}\, c_L\right)\right)$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|L(e)} = {} & \alpha\left(p * U_{c_L,e=1,'tie'} + (1-p)U_{c_L,e=1,'lose'}\right) + (1-\alpha)(p^2 * U_{c_L,e=1,'tie'} \\ & + p(1-p)U_{c_L,e=1,'win'} + (1-p)p * U_{c_L,e=1,'lose'} + (1-p)(1-p)U_{c_L,e=1,'tie'})\end{aligned}$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|L(e)} = {} & \alpha\left(\frac{1}{2}p\left(\left(\frac{1}{3}\, c_H - \theta e_i\right) + \left(\frac{1}{3}\, c_L - \theta e_i\right)\right) + (1-p)\left(\frac{1}{3}c_H - \theta e_i\right)\right) \\ & + (1-\alpha)\left(p^2 * \frac{1}{2}\left(\left(\frac{1}{3}c_L - \theta e_i\right) + \left(\frac{1}{3}c_L - \theta e_i\right)\right) + p(1-p)\left(\frac{1}{3}\, c_L - \theta e_i\right)\right. \\ & + (1-p)p * \left(\frac{1}{3}\, c_L - \theta e_i\right) \\ & \left. + (1-p)(1-p)\left(\frac{1}{2}\left(\left(\frac{1}{3}\, c_L - \theta e_i\right) + \left(\frac{1}{3}\, c_L - \theta e_i\right)\right)\right)\right)\end{aligned}$$

Worker i will exert effort if:

$$\left(-\frac{1}{2}\alpha p + \alpha\right)\frac{1}{3}\, c_H + \left(\frac{1}{2}\alpha p + (1-\alpha)\right)\frac{1}{3}c_L - \theta e_i > \alpha * \frac{1}{3}\, c_H + (1-\alpha)\frac{1}{3}\, c_L$$

$$\left(-\frac{1}{2}\alpha p\right)\left(\frac{1}{3}\, c_H - \frac{1}{3}c_L\right) > \theta e_i$$

Appendix II: Basic setting with reputational concerns

If the worker is high-ability, he does not have to decide on an effort level; in the current setting, effort exertion is impossible. Thus, the strategy sets of both players are the same: when they are assigned low ability, the worker decides to invest in signalling through effort exertion, or to refrain from signalling.

Case 1

Given equilibrium strategy K(e) of worker j, what are the conditions under which worker i with low ability will exert effort?

$$\mathrm{U}_{i,c_L,e=0|K(e)} = \alpha * U_{c_L,e=0,'lose'} + (1-\alpha)(U_{c_L,e=0,'tie'})$$

$$\mathrm{U}_{i,c_L,e=0|K(e)} = \alpha\frac{1}{3}\, c_H + (1-\alpha)\left(\frac{1}{2}\left(\frac{1}{3}\, c_L + I_i\, B_i\right) + \frac{1}{2} * \frac{1}{3}\, c_L\right)$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|K(e)} = {} & \alpha\left(p * U_{c_L,e=1'tie'} + (1-p)U_{c_L,e=1,'lose'}\right) \\ & + (1-\alpha)\left(p * U_{c_L,e=1'win'} + (1-p)U_{c_L,e=1'tie'}\right)\end{aligned}$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|K(e)} = {} & \alpha\left(p\left(\frac{1}{2} * \left(\frac{1}{3}\, c_L + I_i\, B_i - \theta e_i\right) + \frac{1}{2} * \left(\frac{1}{3}\, c_H - \theta e_i\right)\right) + (1-p)\left(\frac{1}{3}\, c_H - \theta e_i\right)\right) \\ & + (1-\alpha)\left(p\left(\frac{1}{3}\, c_L + I_i\, B_i - \theta e_i\right)\right. \\ & \left. + (1-p)\left(\frac{1}{2} * \left(\frac{1}{3}\, c_L + I_i\, B_i - \theta e_i\right) + \frac{1}{2} * \left(\frac{1}{3}\, c_L - \theta e_i\right)\right)\right)\end{aligned}$$

He will exert effort if $\mathrm{U}_{i,c_L,e=1|K(e)} > \mathrm{U}_{i,c_L,e=0|K(e)}$.

$$\alpha\left(p\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L\,+\,I_i\,B_i-\,\theta e_i\right)+\frac{1}{2}*\left(\frac{1}{3}\,c_H-\,\theta e_i\right)\right)+(1-p)\left(\frac{1}{3}\,c_H-\,\theta e_i\right)\right)$$
$$+(1-\alpha)\left(p\left(\frac{1}{3}\,c_L\,+\,I_i\,B_i-\,\theta e_i\right)\right.$$
$$\left.+(1-p)\left(\frac{1}{2}*\left(\frac{1}{3}\,c_L\,+\,I_i\,B_i-\,\theta e_i\right)+\frac{1}{2}*\left(\frac{1}{3}\,c_L-\,\theta e_i\right)\right)\right)$$
$$>\alpha\frac{1}{3}\,c_H+(1-\alpha)\left(\frac{1}{2}\left(\frac{1}{3}\,c_L+\,I_i\,B_i\right)+\frac{1}{2}*\frac{1}{3}\,c_L\right)$$

$$\left(\frac{1}{2}ap+(1-a)\big(p+(1-p)\big)-(1-a)\right)\frac{1}{3}\,c_L+\left(\frac{1}{2}ap+a(1-p)-a\right)\frac{1}{3}\,c_H$$
$$+\left(\frac{1}{2}ap+(1-a)\left(p+\frac{1}{2}(1-p)-\frac{1}{2}\right)\right)I_i\,B_i>\theta e_i$$
$$\left(\frac{1}{2}ap\right)\frac{1}{3}\,c_L+\left(-\frac{1}{2}ap\right)\frac{1}{3}\,c_H+\left(\frac{1}{2}p\right)I_i\,B_i>\theta e_i$$
$$\left(\frac{1}{2}p\right)I_i\,B_i>\theta e_i+\frac{1}{2}ap\left(\frac{1}{3}\,c_H-\frac{1}{3}\,c_L\right)$$

Case 2

If the worker faces a different effort strategy from his co-worker, L(e), worker j does exert effort when he is assigned low ability. How will worker i, with low creative ability act? He derives utility from both actions as follows.

$$\mathrm{U}_{i,c_L,e=0|L(e)}=\alpha*U_{c_L,e=0,'lose'}+(1-\alpha)(pU_{c_L,e=0,'lose'}+(1-p)U_{c_L,e=0,'tie'})$$
$$\mathrm{U}_{i,c_L,e=0|L(e)}=\alpha*\frac{1}{3}\,c_H+(1-\alpha)\left(p*\frac{1}{3}\,c_L+(1-p)\left(\frac{1}{2}\left(\frac{1}{3}\,c_L+I_i\,B_i\right)+\frac{1}{2}\left(\frac{1}{3}\,c_L\right)\right)\right)$$
$$\mathrm{U}_{i,c_L,e=1|L(e)}=\alpha\big(p*U_{c_L,e=1,'tie'}+(1-p)U_{c_L,e=1,'lose'}\big)+(1-\alpha)(p^2*U_{c_L,e=1,'tie'}$$
$$+p(1-p)U_{c_L,e=1,'win'}+(1-p)p*U_{c_L,e=1,'lose'}+(1-p)(1-p)U_{c_L,e=1,'tie'})$$

$$\mathrm{U}_{i,c_L,e=1|L(e)}=\alpha\left(p\left(\frac{1}{2}\left(\frac{1}{3}\,c_H-\theta e_i\right)+\frac{1}{2}\left(\frac{1}{3}\,c_L\,+I_i\,B_i-\theta e_i\right)\right)+(1-p)(\frac{1}{3}c_H-\theta e_i)\right)$$
$$+(1-\alpha)\left(p^2\left(\frac{1}{2}\left(\frac{1}{3}c_L-\theta e_i\right)+\frac{1}{2}\left(\frac{1}{3}c_L+\,I_i\,B_i-\theta e_i\right)\right)\right.$$
$$+p(1-p)\left(\frac{1}{3}\,c_L\,+I_i\,B_i-\theta e_i\right)+(1-p)p*\left(\frac{1}{3}\,c_L\,-\theta e_i\right)$$
$$\left.+(1-p)(1-p)\left(\frac{1}{2}\left(\frac{1}{3}\,c_L-\theta e_i\right)+\frac{1}{2}\left(\frac{1}{3}\,c_L\,+I_i\,B_i-\theta e_i\right)\right)\right)$$

Worker i will exert effort if:

$$\alpha\left(\frac{1}{2}p\left(\left(\frac{1}{3}\ c_H-\ \theta e_i\right)+\left(\frac{1}{3}\ c_L\ +I_i\ B_i-\theta e_i\right)\right)+(1-p)(\frac{1}{3}c_H-\theta e_i)\right)$$
$$+(1-\alpha)\left(p^2*\frac{1}{2}\left(\left(\frac{1}{3}c_L-\theta e_i\right)+\left(\frac{1}{3}c_L+\ I_i\ B_i-\theta e_i\right)\right)\right.$$
$$+p(1-p)\left(\frac{1}{3}\ c_L\ +I_i\ B_i-\theta e_i\right)+(1-p)p*\left(\frac{1}{3}\ c_L\ -\theta e_i\right)$$
$$\left.+(1-p)(1-p)\left(\frac{1}{2}\left(\left(\frac{1}{3}\ c_L-\theta e_i\right)+\left(\frac{1}{3}\ c_L\ +I_i\ B_i-\theta e_i\right)\right)\right)\right)$$
$$>\ \alpha*\frac{1}{3}\ c_H+(1-\alpha)\left(\left(p*\frac{1}{3}\ c_L\right)+(1-p)\frac{1}{2}\left(\left(\frac{1}{3}\ c_L+I_i\ B_i\right)+\ \frac{1}{3}\ c_L\right)\right)$$

Given that 0<p<1 and 0<α<1,

$$\alpha(-\theta e_i)+(1-\alpha)\left(p^2+p(1-p)+(1-p)p+(1-p)(1-p)\right)(-\theta e_i)=-\theta e_i$$

$$\alpha\left(\frac{1}{2}p\left(\left(\frac{1}{3}\ c_H\right)+\left(\frac{1}{3}\ c_L\ +I_i\ B_i\right)\right)+(1-p)(\frac{1}{3}c_H)\right)$$
$$+(1-\alpha)\left(p^2*\frac{1}{2}\left(\left(\frac{1}{3}c_L\right)+\left(\frac{1}{3}c_L+\ I_i\ B_i\right)\right)+p(1-p)\left(\frac{1}{3}\ c_L\ +I_i\ B_i\right)+(1-p)p\right.$$
$$\left.*\left(\frac{1}{3}\ c_L\right)+(1-p)(1-p)\left(\frac{1}{2}\left(\left(\frac{1}{3}\ c_L\right)+\left(\frac{1}{3}\ c_L\ +I_i\ B_i\right)\right)\right)\right)-\theta e_i$$
$$>\ \alpha*\frac{1}{3}\ c_H+(1-\alpha)\left(\left(p*\frac{1}{3}\ c_L\right)+(1-p)\frac{1}{2}\left(\left(\frac{1}{3}\ c_L+I_i\ B_i\right)+\left(\frac{1}{3}\ c_L\right)\right)\right)$$

$$\left(\frac{1}{2}\alpha p+(1-\alpha)\left(\frac{1}{2}p^2+p(1-p)+\frac{1}{2}(1-p)(1-p)-\frac{1}{2}(1-p)\right)\right)I_i\ B_i$$
$$>\theta e_i+\left(-\frac{1}{2}\alpha p-(1-\alpha)+(1-\alpha)\ \right)\frac{1}{3}c_L+\left(\alpha-\frac{1}{2}\alpha p-\alpha(1-p)\right)\frac{1}{3}\ c_H$$

$$\left(\frac{1}{2}\alpha p+(1-\alpha)\left(\frac{1}{2}p^2+p(1-p)+\frac{1}{2}(1-p)(1-p)-\frac{1}{2}(1-p)\right)\right)I_i\ B_i$$
$$=\left(\frac{1}{2}\alpha p+\left(\frac{1}{2}p\right)-\alpha\left(\frac{1}{2}p\right)\right)I_i\ B_i=\frac{1}{2}pI_i\ B_i$$

$$\left(\frac{1}{2}p\right)I_i\ B_i>\theta e_i+\left(-\frac{1}{2}\alpha p\ \right)\frac{1}{3}c_L+\left(\frac{1}{2}\alpha p\right)\frac{1}{3}\ c_H$$

$$\left(\frac{1}{2}p\right)I_i\ B_i>\theta e_i+\frac{1}{2}\alpha p\left(\frac{1}{3}\ c_H-\frac{1}{3}\ c_L\right)$$

Appendix III: Extended setting with reputational concerns

A1.1 The supervisor's decisions

With the inclusion of new signals, the supervisor can be faced with new scenario's. Since the supervisor is not concerned about his reputation in the model, the decisions for scenario's 1-4 are extended to this new game. I will now establish his optimal decisions for scenario's 5-8.

Scenario 5

In this scenario, the supervisor receives a superior signal from worker i and a low creative ability signal from worker j. His expected utility from implementing each idea is as follows.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H{}^+}) = \frac{1}{3}c_H$$

$$\mathrm{E}(U_s|\mathrm{s}_{j,c_L}) = \frac{1}{3}c_L$$

$$E(U_s|\mathrm{s}_{i,c_H{}^+}) > \mathrm{E}(U_s|\mathrm{s}_{j,c_L})$$

Thus, the supervisor will decide to implement the idea of worker I.

$$D(c) = c_i$$

Scenario 6

In scenario 6, the supervisor receives a superior ability signal from worker i and a high creative ability signal from worker j; implementation of each idea results in the following expected utility gains.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H{}^+}) = \frac{1}{3}c_H$$

$$\mathrm{E}(U_s|\mathrm{s}_{j,c_H}) = (1-\alpha)p\frac{1}{3}c_L + \alpha\frac{1}{3}c_H$$

$$E(U_s|\mathrm{s}_{i,c_H{}^+}) > \mathrm{E}(U_s|\mathrm{s}_{j,c_H})$$

Thus, the supervisor will again decide to implement the idea of worker i.

$$D(c) = c_i$$

Scenario 7

In the seventh scenario, the supervisor receives superior signals from both workers. The expected utilities from both ideas are thus equally high.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H{}^+}) = \frac{1}{3}c_H$$

$$\mathrm{E}(U_s|\mathrm{s}_{j,c_H{}^+}) = \frac{1}{3}c_H$$

$$E(U_s|\mathrm{s}_{i,c_H{}^+}) = \mathrm{E}(U_s|\mathrm{s}_{j,c_H{}^+})$$

The supervisor will randomly decide to implement one of the ideas.

$$D(c) = (c_i, c_j)\ with\ \left(\frac{1}{2}, \frac{1}{2}\right)$$

Scenario 8

This scenario is the inverse of scenario 5; the supervisor receives a superior signal from worker j and a signal of low creative ability from worker i. His expected utility gains are as follows.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_L}) = \frac{1}{3}c_L$$

$$\mathrm{E}(U_s|\mathrm{s}_{j,c_H{}^+}) = \frac{1}{3}c_H$$

$$E(U_s|\mathrm{s}_{i,c_H}) < \mathrm{E}(U_s|\mathrm{s}_{j,c_L})$$

Thus, the supervisor decides to implement worker j's idea.

$$D(c) = c_j$$

Scenario 9

Here, the supervisor receives a high ability signal from worker i and a superior signal from worker j. Expected utility gains are represented below.

$$\mathrm{E}(U_s|\mathrm{s}_{i,c_H}) = (1-\alpha)p\frac{1}{3}c_L + \alpha\frac{1}{3}c_H$$
$$\mathrm{E}(U_s|\mathrm{s}_{j,c_H{}^+}) = \frac{1}{3}c_H$$
$$E(U_s|\mathrm{s}_{i,c_H}) < \mathrm{E}(U_s|\mathrm{s}_{j,c_L})$$

Again, the supervisor will decide to implement the idea of worker j.

$$D(c) = c_j$$

A1.2 The worker's decision

Case 1, revisited

Worker i with high creative ability c_H, against strategy K, exerts effort if $\mathrm{U}_{i,c_H,e=1|K(s)} > \mathrm{U}_{i,c_H,e=0|K(s)}$.

$$\mathrm{U}_{i,c_H,e=0|K(s)} = \alpha\left(\frac{1}{2}U_{c_H,e=0,'win'} + \frac{1}{2}U_{c_H,e=0,'lose'}\right) + (1-\alpha)U_{c_H,e=0,'win'}$$

$$\mathrm{U}_{i,c_H,e=0|K(s)} = \alpha\left(\frac{1}{2}(\frac{1}{3}c_H + I_iB_i) + \frac{1}{2}\left(\frac{1}{3}c_H\right)\right) + (1-\alpha)(\frac{1}{3}c_H + I_iB_i)$$

$$\mathrm{U}_{i,c_H,e=1|K(s)} = \alpha\left(p * U_{c_H,e=1,'win'} + (1-p)\left(\frac{1}{2}U_{c_H,e=1,'win'} + \frac{1}{2}U_{c_H,e=1,'lose'}\right)\right) + (1-\alpha)\left(p * U_{c_H,e=1,'win'} + (1-p)U_{c_H,e=1,'win'}\right)$$

$$\mathrm{U}_{i,c_H,e=1|K(s)} = \alpha\left(p * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{2} * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + \frac{1}{2} * \left(\frac{1}{3}c_H - \theta e_i\right)\right)\right) + (1-\alpha)\left(p * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right)\right)$$

$$\alpha\left(p * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{2} * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + \frac{1}{2} * \left(\frac{1}{3}c_H - \theta e_i\right)\right)\right) + (1-\alpha)\left(p * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right)\right) > \alpha\left(\frac{1}{2}(\frac{1}{3}c_H + I_iB_i) + \frac{1}{2}\left(\frac{1}{3}c_H\right)\right) + (1-\alpha)(\frac{1}{3}c_H + I_iB_i)$$

$$\left(\left(\alpha p + \frac{1}{2}\alpha(1-p)\right) + (1-\alpha) - \frac{1}{2}\alpha - (1-\alpha)\right)I_iB_i + \frac{1}{3}c_H > +\frac{1}{3}c_H + \theta e_i$$

$$\left(\left(\alpha p + \frac{1}{2}\alpha(1-p)\right) - \frac{1}{2}\alpha\right)I_iB_i > \theta e_i$$

$$\left(\frac{1}{2}\alpha p\right)I_iB_i > \theta e_i$$

So, worker i exerts effort if $\frac{1}{2}\alpha p B_i > \frac{1}{2}\theta$

Case 2, revisited

If worker i is attributed high creative ability, and faces strategy L(e),

$$\mathrm{U}_{i,c_H,e=0|L(e)} = \alpha\left(\frac{1}{2}U_{c_H,e=0,'win'} + \frac{1}{2}U_{c_H,e=0,'lose'}\right) + (1-\alpha)(p(\frac{1}{2}U_{c_H,e=0,'win'} + \frac{1}{2}U_{c_H,e=0,'lose'}) + (1-p) * U_{c_H,e=0,'win'})$$

$$\mathrm{U}_{i,c_H,e=0|L(e)} = \alpha\left(\frac{1}{2}(\frac{1}{3}c_H + I_iB_i) + \frac{1}{2}\left(\frac{1}{3}c_H\right)\right) + (1-\alpha)\left(p\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right) + (1-p)\left(\frac{1}{3}c_H + I_iB_i\right)\right)$$

$$\mathrm{U}_{i,c_H,e=1|L(e)} = \alpha\left(p * U_{c_H,e=0,'win'} + (1-p)(\frac{1}{2}U_{c_H,e=0,'win'} + \frac{1}{2}U_{c_H,e=0,'lose'})\right) + (1-\alpha)(pU_{c_H,e=0,'win'} + (1-p)U_{c_H,e=0,'win'})$$

$$\mathrm{U}_{i,c_H,e=1|L(e)} = \alpha\left(p * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H - \theta e_i\right)\right) + (1-\alpha)\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right)$$

Worker i will exert effort if: $\mathrm{U}_{i,c_H,e=1|L(s)} > \mathrm{U}_{i,c_H,e=0|L(s)}$

$$\alpha\left(p * \left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H - \theta e_i\right)\right) + (1-\alpha)\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) > \alpha\left(\frac{1}{2}(\frac{1}{3}c_H + I_iB_i) + \frac{1}{2}\left(\frac{1}{3}c_H\right)\right) + (1-\alpha)\left(p\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right) + (1-p)\left(\frac{1}{3}c_H + I_iB_i\right)\right)$$

$$\left(\alpha\left(p + \frac{1}{2}(1-p)\right) + (1-\alpha)\right)I_iB_i - \frac{1}{2}\alpha I_iB_i - \frac{1}{2}(1-\alpha)pI_iB_i - (1-\alpha)(1-p)I_iB_i = \left(\alpha\left(p + \frac{1}{2} - \frac{1}{2}p\right) + (1-\alpha)\right)I_iB_i - \frac{1}{2}\alpha I_iB_i - \frac{1}{2}(1-\alpha)pI_iB_i - (1-\alpha)(1-p)I_iB_i = -\frac{1}{2}pI_iB_i - (-p)I_iB_i = -\frac{1}{2}pI_iB_i - (-p)I_iB_i = \frac{1}{2}pI_iB_i$$

$$\left(\frac{1}{2}p\right)I_iB_i > \theta e_i - \frac{1}{3}c_H + (\alpha + \frac{1}{2}(1-\alpha)p + (1-\alpha)(1-p))\frac{1}{3}c_H + \frac{1}{2}(1-\alpha)p\frac{1}{3}c_L$$

$$\frac{1}{2}pI_iB_i > \theta e_i + (-\frac{1}{2}p + \frac{1}{2}\alpha p)\frac{1}{3}c_H + \frac{1}{2}(1-\alpha)p\frac{1}{3}c_L$$

$$\frac{1}{2}pI_iB_i > \theta e_i + \left(\frac{1}{2}p(\alpha-1)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)$$

Thus, the worker will exert effort if

$$\frac{1}{2}pB_i - \left(\frac{1}{2}p(\alpha-1)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right) > \theta$$

Case 3

3.a Low ability

If worker i with c_L faces strategy M(e). Co-worker j now exerts effort only when he is high ability. Worker i will exert effort if $\mathrm{U}_{i,c_L,e=1|M(e)} > \mathrm{U}_{i,c_L,e=0|M(e)}$.

$$\mathrm{U}_{i,c_L,e=0|M(e)} = \alpha\left(pU_{c_L,e=0,'lose'} + (1-p)U_{c_L,e=0,'lose'}\right) + (1-\alpha)\left(\frac{1}{2} * U_{c_L,e=0,'win'} + \frac{1}{2} * U_{c_L,e=0,'lose'}\right)$$

$$\mathrm{U}_{i,c_L,e=0|M(e)} = \alpha\left(p\frac{1}{3}c_H + (1-p)\frac{1}{3}c_H\right) + (1-\alpha)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right)$$

$$\mathrm{U}_{i,c_L,e=1|M(e)} = \alpha\left(p^2 * U_{c_L,e=0,'lose'} + p(1-p)\left(\frac{1}{2}U_{c_L,e=0,'win'} + \frac{1}{2}U_{c_L,e=0,'lose'}\right) + (1-p)p * U_{c_L,e=0,'lose'} + (1-p)(1-p) * U_{c_L,e=0,'lose'}\right) + (1-\alpha)\left(p * U_{c_L,e=0,'win'} + (1-p)\left(\frac{1}{2}U_{c_L,e=0,'win'} + \frac{1}{2}U_{c_L,e=0,'lose'}\right)\right)$$

$$\mathrm{U}_{i,c_L,e=1|M(e)} = \alpha\left(p^2\left(\frac{1}{3}c_H - \theta e_i\right) + p(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H - \theta e_i\right)\right) + (1-p)p * \left(\frac{1}{3}c_H - \theta e_i\right) + (1-p)(1-p)\left(\frac{1}{3}c_H - \theta e_i\right)\right) + (1-\alpha)\left(p\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L - \theta e_i\right)\right)\right)$$

$$\alpha\left(p^2\left(\frac{1}{3}c_H - \theta e_i\right) + p(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H - \theta e_i\right)\right) + (1-p)p * \left(\frac{1}{3}c_H - \theta e_i\right) + (1-p)(1-p)\left(\frac{1}{3}c_H - \theta e_i\right)\right) + (1-\alpha)\left(p\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + (1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L - \theta e_i\right)\right)\right) > \alpha\frac{1}{3}c_H + (1-\alpha)\left(\frac{1}{3}c_L + \frac{1}{2}I_iB_i\right)$$

$$\alpha\left(p^2\left(\frac{1}{3}c_H\right) + p(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H\right)\right) + (1-p)p * \left(\frac{1}{3}c_H\right) + (1-p)(1-p)\left(\frac{1}{3}c_H\right)\right) + (1-\alpha)\left(\frac{1}{3}c_L + p(I_iB_i) + (1-p)\frac{1}{2}I_iB_i\right) > \alpha\frac{1}{3}c_H + (1-\alpha)\left(\frac{1}{2}I_iB_i + \frac{1}{3}c_L\right) + \theta e_i$$

$$\left(\frac{1}{2}\alpha p(1-p)+(1-\alpha)\left(p+\frac{1}{2}(1-p)\right)-\frac{1}{2}(1-\alpha)\right)I_iB_i$$
$$=\left(\frac{1}{2}\alpha p-\frac{1}{2}\alpha p^2+p+\frac{1}{2}(1-p)-\alpha p-\frac{1}{2}\alpha(1-p)-\frac{1}{2}+\frac{1}{2}\alpha\right)I_iB_i$$
$$=\left(\frac{1}{2}\alpha p-\frac{1}{2}\alpha p^2+p+\frac{1}{2}-\frac{1}{2}p-\alpha p-\frac{1}{2}\alpha+\frac{1}{2}\alpha p-\frac{1}{2}+\frac{1}{2}\alpha\right)I_iB_i$$
$$=\left(-\frac{1}{2}\alpha p^2+\frac{1}{2}p\right)I_iB_i=\left(\frac{1}{2}p(1-\alpha p)\right)I_iB_i$$

$$\left(-\alpha p^2-\frac{1}{2}\alpha p(1-p)-\alpha p(1-p)-\alpha(1-p)(1-p)+\alpha\right)\frac{1}{3}c_H$$
$$=\left(-\alpha p^2-\frac{1}{2}\alpha p+\frac{1}{2}\alpha p^2-\alpha p+\alpha p^2-\alpha+2\alpha p-\alpha p^2+\alpha\right)\frac{1}{3}c_H$$
$$=\left(-\frac{1}{2}\alpha p^2+\frac{1}{2}\alpha p\right)\frac{1}{3}c_H=\left(\frac{1}{2}\alpha p(1-p)\right)\frac{1}{3}c_H$$

$$\left(-\frac{1}{2}\alpha p(1-p)-(1-\alpha)+(1-\alpha)\right)\frac{1}{3}c_L=\left(-\frac{1}{2}\alpha p(1-p)\right)\frac{1}{3}c_L$$

$$\left(-\frac{1}{2}\alpha p^2+\frac{1}{2}p\right)I_iB_i>\theta e_i+\left(-\frac{1}{2}\alpha p(1-p)\right)\frac{1}{3}c_L+\left(\frac{1}{2}\alpha p(1-p)\right)\frac{1}{3}c_H$$

So, worker i with low ability will exert effort, when facing strategy M(e), if

$$\left(-\frac{1}{2}\alpha p^2+\frac{1}{2}p\right)B_i>\theta+\left(\frac{1}{2}\alpha p\,(1-p)\right)\left(\frac{1}{3}c_H-\frac{1}{3}c_L\right)$$

3.b High ability

If worker i is attributed high ability and dealing with strategy M(e), he will exert effort if

$\mathrm{U}_{i,c_H,e=1|M(e)}>\mathrm{U}_{i,c_H,e=0|M(e)}$

$$\mathrm{U}_{i,c_H,e=0|M(e)}=\alpha\left(p*U_{c_H,e=0,'lose'}+(1-p)\left(\frac{1}{2}*U_{c_H,e=0,'win'}+\frac{1}{2}*U_{c_H,e=0,'lose'}\right)\right)+(1-\alpha)*U_{c_H,e=0,'win'}$$

$$\mathrm{U}_{i,c_H,e=0|M(e)}=\alpha\left(p*\frac{1}{3}c_H+(1-p)\left(\frac{1}{2}(\frac{1}{3}c_H+I_iB_i)+\frac{1}{2}(\frac{1}{3}c_H)\right)\right)+(1-\alpha)\left(\frac{1}{3}c_H+I_iB_i\right)$$

$$\mathrm{U}_{i,c_H,e=1|M(e)}=\alpha\left(p^2\left(\frac{1}{2}*U_{c_H,e=1,'win'}+\frac{1}{2}*U_{c_H,e=1,'lose'}\right)+p(1-p)*U_{c_H,e=1,'win'}+(1-p)p*U_{c_{H,e=1,'lose'}}+(1-p)(1-p)\left(\frac{1}{2}*U_{c_H,e=1,'win'}+\frac{1}{2}*U_{c_H,e=1,'lose'}\right)\right)+(1-\alpha)\left(p*U_{c_H,e=1,'win'}+(1-p)U_{c_H,e=1,'win'}\right)$$

$$\mathrm{U}_{i,c_H,e=1|M(e)}=\alpha\left(p^2\left(\frac{1}{2}*(\frac{1}{3}c_H+I_iB_i-\theta e_i)+\frac{1}{2}(\frac{1}{3}c_H-\theta e_i)\right)+p(1-p)(\frac{1}{3}c_H+I_iB_i-\theta e_i)+(1-p)p(\frac{1}{3}c_H-\theta e_i)+(1-p)(1-p)\left(\frac{1}{2}(\frac{1}{3}c_H+I_iB_i-\theta e_i)+\frac{1}{2}(\frac{1}{3}c_H-\theta e_i)\right)\right)+(1-\alpha)\left(p(\frac{1}{3}c_H+I_iB_i-\theta e_i)+(1-p)(\frac{1}{3}c_H+I_iB_i-\theta e_i)\right)$$

Worker i will exert effort if

$$\alpha\left(p^2\left(\frac{1}{2}*(\frac{1}{3}c_H+I_iB_i-\theta e_i)+\frac{1}{2}(\frac{1}{3}c_H-\theta e_i)\right)+p(1-p)(\frac{1}{3}c_H+I_iB_i-\theta e_i)+(1-p)p(\frac{1}{3}c_H-\theta e_i)+(1-p)(1-p)\left(\frac{1}{2}(\frac{1}{3}c_H+I_iB_i-\theta e_i)+\frac{1}{2}(\frac{1}{3}c_H-\theta e_i)\right)\right)+(1-\alpha)\left(p(\frac{1}{3}c_H+I_iB_i-\theta e_i)+(1-p)(\frac{1}{3}c_H+I_iB_i-\theta e_i)\right)>\alpha\left(p*\frac{1}{3}c_H+(1-p)\left(\frac{1}{2}(\frac{1}{3}c_H+I_iB_i)+\frac{1}{2}(\frac{1}{3}c_H)\right)\right)+(1-\alpha)\left(\frac{1}{3}c_H+I_iB_i\right)$$

$$\alpha\left(p^2\left(\frac{1}{3}c_H+\frac{1}{2}I_iB_i\right)+p(1-p)(\frac{1}{3}c_H+I_iB_i)+(1-p)p(\frac{1}{3}c_H)+(1-p)(1-p)\left(\frac{1}{3}c_H+\frac{1}{2}I_iB_i\right)\right)+(1-\alpha)\left(\frac{1}{3}c_H+I_iB_i\right)-\theta e_i>\alpha\left(\frac{1}{3}c_H+(1-p)\left(\frac{1}{2}I_iB_i\right)\right)+(1-\alpha)\left(\frac{1}{3}c_H+I_iB_i\right)$$

$$\alpha\left(\frac{1}{3}c_H+p^2\left(\frac{1}{2}I_iB_i\right)+p(1-p)I_iB_i+(1-p)(1-p)\frac{1}{2}I_iB_i\right)+(1-\alpha)\left(\frac{1}{3}c_H+I_iB_i\right)>\theta e_i+\alpha\left(\frac{1}{3}c_H+(1-p)\left(\frac{1}{2}I_iB_i\right)\right)+(1-\alpha)\left(\frac{1}{3}c_H+I_iB_i\right)$$

$$\frac{1}{3}c_H+\alpha\left(p^2\left(\frac{1}{2}I_iB_i\right)+p(1-p)I_iB_i+(1-p)(1-p)\frac{1}{2}I_iB_i\right)+(1-\alpha)(I_iB_i)-\alpha\left((1-p)\left(\frac{1}{2}I_iB_i\right)\right)-(1-\alpha)(I_iB_i)>\theta e_i+\frac{1}{3}c_H$$

$$\alpha\left(p^2\left(\frac{1}{2}I_iB_i\right)+p(1-p)I_iB_i+(1-p)(1-p)\frac{1}{2}I_iB_i\right)-\alpha\left((1-p)\left(\frac{1}{2}I_iB_i\right)\right)>\frac{1}{2}\theta e_i$$

$$\alpha\left(\frac{1}{2}p^2+p(1-p)+\frac{1}{2}(1-p)(1-p)-\frac{1}{2}(1-p)\right)I_iB_i>\theta e_i$$

So, worker i with high creative ability will exert effort, when facing strategy M(e), if $\left(\frac{1}{2}ap\right)B_i>\theta$

Case 4

4.a Low ability

When low ability worker i faces strategy N(e). Worker j exerts effort no matter his ability level. Worker i will now exert effort if $U_{i,c_L,e=1|N(e)} > U_{i,c_L,e=0|N(e)}$.

$$U_{i,c_L,e=0|N(e)}=\alpha(p*U_{c_L,e=0,'lose'}+(1-p)U_{c_L,e=0,'lose'})+(1-\alpha)\left(p*U_{c_L,e=0,'lose'}+(1-p)\left(\frac{1}{2}U_{c_L,e=0,'win'}+\frac{1}{2}U_{c_L,e=0,'lose'}\right)\right)$$

$$U_{i,c_L,e=0|N(e)}=\alpha\left(\frac{1}{3}c_H\right)+(1-\alpha)\left(p*\frac{1}{3}c_L+(1-p)\left(\frac{1}{2}(\frac{1}{3}c_L+I_iB_i)+\frac{1}{2}(\frac{1}{3}c_L)\right)\right)$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|N(e)} = \alpha\Big(&p^2 * U_{c_L,e=1,'lose'} + p(1-p)\left(\frac{1}{2}U_{c_L,e=1,'win'} + \frac{1}{2}U_{c_L,e=1,'lose'}\right)\\ &+ (1-p)pU_{c_L,e=1,'lose'} + (1-p)(1-p)U_{c_L,e=1,'lose'}\Big)\\ &+ (1-\alpha)\Big(p^2\left(\frac{1}{2}U_{c_L,e=1,'win'} + \frac{1}{2}U_{c_L,e=1,'lose'}\right) + p(1-p)\left(U_{c_L,e=1,'win'}\right)\\ &+ (1-p)p\left(U_{c_L,e=1,'lose'}\right) + (1-p)(1-p)\left(\frac{1}{2}U_{c_L,e=1,'win'} + \frac{1}{2}U_{c_L,e=1,'lose'}\right)\Big)\end{aligned}$$

$$\begin{aligned}\mathrm{U}_{i,c_L,e=1|N(e)} = \alpha\Big(&p^2(\frac{1}{3}c_H - \theta e_i) + p(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H - \theta e_i\right)\right)\\ &+ (1-p)p\left(\frac{1}{3}c_H - \theta e_i\right) + (1-p)(1-p)\left(\frac{1}{3}c_H - \theta e_i\right)\Big)\\ &+ (1-\alpha)\Big(p^2\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L - \theta e_i\right)\right)\\ &+ p(1-p)\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + (1-p)p\left(\frac{1}{3}c_L - \theta e_i\right)\\ &+ (1-p)(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L - \theta e_i\right)\right)\Big)\end{aligned}$$

$$\begin{aligned}&\alpha\Big(p^2(\frac{1}{3}c_H) + p(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H\right)\right) + (1-p)p\left(\frac{1}{3}c_H\right) + (1-p)(1-p)\left(\frac{1}{3}c_H\right)\Big)\\ &\quad + (1-\alpha)\Big(p^2\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right) + p(1-p)\left(\frac{1}{3}c_L + I_iB_i\right)\\ &\quad + (1-p)p\left(\frac{1}{3}c_L\right) + (1-p)(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_L + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right)\Big) - \theta e_i\\ &\quad > \alpha\left(\frac{1}{3}c_H\right) + (1-\alpha)\left(p * \frac{1}{3}c_L + (1-p)\left(\frac{1}{2}(\frac{1}{3}c_L + I_iB_i) + \frac{1}{2}(\frac{1}{3}c_L)\right)\right)\end{aligned}$$

$$\begin{aligned}&\left(\frac{1}{2}\alpha p - \frac{1}{2}\alpha p^2 + (1-\alpha)\left(\frac{1}{2}p^2 + p - p^2 + \frac{1}{2} - p + \frac{1}{2}p^2\right) - \frac{1}{2}(1-\alpha)(1-p)\right)I_iB_i\\ &\quad = \Big(\frac{1}{2}\alpha p - \frac{1}{2}\alpha p^2 + \frac{1}{2}p^2 + p - p^2 + \frac{1}{2} - p + \frac{1}{2}p^2 - \frac{1}{2}\alpha p^2 - \alpha p + \alpha p^2 - \frac{1}{2}\alpha + \alpha p\\ &\quad - \frac{1}{2}\alpha p^2 - \frac{1}{2} + \frac{1}{2}\alpha + \frac{1}{2}p - \frac{1}{2}\alpha p\Big)I_iB_i = \left(-\frac{1}{2}\alpha p^2 + \frac{1}{2}p\right)I_iB_i\end{aligned}$$

$$\begin{aligned}&\left(-\alpha p^2 - \frac{1}{2}\alpha p(1-p) - (1-p)\alpha p - \alpha(1-p)(1-p) + \alpha\right)\frac{1}{3}c_H = \left(-\frac{1}{2}\alpha p^2 + \frac{1}{2}\alpha p\right)\frac{1}{3}c_H\\ &\quad = \left(\frac{1}{2}\alpha p(1-p)\right)\frac{1}{3}c_H\end{aligned}$$

$$\left(-\frac{1}{2}\alpha p(1-p) - (1-\alpha) + (1-\alpha)\right)\frac{1}{3}c_L = \left(-\frac{1}{2}\alpha p(1-p)\right)\frac{1}{3}c_L$$

$$\left(-\frac{1}{2}\alpha p^2 + \frac{1}{2}p\right)I_iB_i > \theta e_i + \left(-\frac{1}{2}\alpha p^2 + \frac{1}{2}\alpha p\right)\frac{1}{3}c_H + (-\frac{1}{2}\alpha p + \frac{1}{2}\alpha p^2)\frac{1}{3}c_L$$

So, worker i with low ability, facing strategy N(e), will decide to exert effort when:

$$\left(\frac{1}{2}p(1-\alpha p)\right)I_iB_i > \theta e_i + \left(\frac{1}{2}\alpha p(1-p)\right)\left(\frac{1}{3}c_H - \frac{1}{3}c_L\right)$$

4.b High ability

When worker i is assigned high ability, given strategy set N(e) by his opponent,

$$\begin{aligned}\mathrm{U}_{i,c_H,e=0|N(e)} = {} & \alpha\left(p * U_{c_H,e=0,'lose'} + (1-p)\left(\frac{1}{2}U_{c_H,e=0,'win'} + \frac{1}{2}U_{c_H,e=0,'lose'}\right)\right) \\ & + (1-\alpha)\left(p\left(\frac{1}{2}U_{c_H,e=0,'win'} + \frac{1}{2}U_{c_H,e=0,'lose'}\right) + (1-p)U_{c_H,e=0,'win'}\right)\end{aligned}$$

$$\begin{aligned}\mathrm{U}_{i,c_H,e=0|N(e)} = {} & \alpha\left(p\left(\frac{1}{3}c_H\right) + (1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H\right)\right)\right) \\ & + (1-\alpha)\left(p\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right) + (1-p)\left(\frac{1}{3}c_H + I_iB_i\right)\right)\end{aligned}$$

$$\begin{aligned}\mathrm{U}_{i,c_H,e=1|N(e)} = {} & \alpha(p^2(\frac{1}{2}U_{c_H,e=1,'win'} + \frac{1}{2}U_{c_H,e=1,'lose'}) + p(1-p)(U_{c_H,e=1,'win'}) \\ & + (1-p)p(U_{c_H,e=1,'lose'}) + (1-p)(1-p)(\frac{1}{2}U_{c_H,e=1,'win'} + \frac{1}{2}U_{c_H,e=1,'lose'})) \\ & + (1-\alpha)(p^2(U_{c_H,e=1,'win'}) + p(1-p)(U_{c_H,e=1,'win'}) + (1-p)p(\frac{1}{2}U_{c_H,e=1,'win'} \\ & + \frac{1}{2}U_{c_H,e=1,'lose'}) + (1-p)(1-p)(U_{c_H,e=1,'win'}))\end{aligned}$$

$$\begin{aligned}\mathrm{U}_{i,c_H,e=1|N(e)} = {} & \alpha\left(p^2\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H - \theta e_i\right)\right) + p(1-p)\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right)\right. \\ & + (1-p)p\left(\frac{1}{3}c_H - \theta e_i\right) \\ & \left. + (1-p)(1-p)\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_H - \theta e_i\right)\right)\right) \\ & + (1-\alpha)\left(p^2\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + p(1-p)\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right)\right. \\ & + (1-p)p\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L - \theta e_i\right)\right) \\ & \left. + (1-p)(1-p)\left(\frac{1}{3}c_H + I_iB_i - \theta e_i\right)\right)\end{aligned}$$

he will exert effort if,

$$\alpha\left(\frac{1}{3}c_H + p^2\left(\frac{1}{2}I_iB_i\right) + p(1-p)I_iB_i + (1-p)(1-p)\left(\frac{1}{2}I_iB_i\right)\right)$$
$$+ (1-\alpha)\left(p^2\left(\frac{1}{3}c_H + I_iB_i\right) + p(1-p)\left(\frac{1}{3}c_H + I_iB_i\right)\right.$$
$$\left. + (1-p)p\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right) + (1-p)(1-p)\left(\frac{1}{3}c_H + I_iB_i\right)\right)$$
$$> \theta e_i + \alpha(\frac{1}{3}c_H + (1-p)\left(\frac{1}{2}I_iB_i\right)$$
$$+ (1-\alpha)\left(p\left(\frac{1}{2}\left(\frac{1}{3}c_H + I_iB_i\right) + \frac{1}{2}\left(\frac{1}{3}c_L\right)\right) + (1-p)\left(\frac{1}{3}c_H + I_iB_i\right)\right)$$

$$\left(\frac{1}{2}\alpha p^2 + \alpha p(1-p) + \frac{1}{2}\alpha(1-p)(1-p) + (1-\alpha)p^2 + (1-\alpha)p(1-p) + \frac{1}{2}(1-\alpha)(1-p)p\right.$$
$$\left. + (1-\alpha)(1-p)(1-p) - \frac{1}{2}\alpha(1-p) - \frac{1}{2}(1-\alpha)p - (1-\alpha)(1-p)\right)I_iB_i$$
$$= \left(\frac{1}{2}\alpha p^2 + \alpha p - \alpha p^2 + \frac{1}{2}\alpha - \alpha p + \frac{1}{2}\alpha p^2 + p^2 - \alpha p^2 + p - p^2 - \alpha p + \alpha p^2 + \frac{1}{2}p\right.$$
$$\left. - \frac{1}{2}p^2 - \frac{1}{2}\alpha p + \frac{1}{2}\alpha p^2 + 1 - 2p + p^2 - \alpha + 2\alpha p - \alpha p^2 - \frac{1}{2}\alpha + \frac{1}{2}\alpha p - \frac{1}{2}p + \frac{1}{2}\alpha p\right.$$
$$\left. - 1 + \alpha + p - \alpha p\right)I_iB_i = \left(-\frac{1}{2}\alpha p^2 + \frac{1}{2}p^2 + \frac{1}{2}\alpha p\right)I_iB_i = \frac{1}{2}p(p - \alpha p + \alpha)I_iB_i$$

$$(\frac{1}{2}(1-\alpha)p - \frac{1}{2}(1-\alpha)(1-p)p)\frac{1}{3}c_L = (\frac{1}{2}p - \frac{1}{2}\alpha p - \frac{1}{2}p + \frac{1}{2}p^2 + \frac{1}{2}\alpha p - \frac{1}{2}\alpha p^2)\frac{1}{3}c_L$$
$$= \left(\frac{1}{2}p^2 - \frac{1}{2}\alpha p^2\right)\frac{1}{3}c_L = (1-\alpha)\frac{1}{2}p^2\frac{1}{3}c_L$$

$$\left(\frac{1}{2}(1-\alpha)p + (1-\alpha)(1-p) - (1-\alpha)p^2 - 1\frac{1}{2}(1-\alpha)p(1-p) - (1-\alpha)(1-p)(1-p)\right)\frac{1}{3}c_H$$
$$= \left(\frac{1}{2}(1-\alpha)p + (1-\alpha)(1-p) - (1-\alpha)p^2 - 1\frac{1}{2}(1-\alpha)p(1-p)\right.$$
$$\left. - (1-\alpha)(1-2p+p^2)\right)\frac{1}{3}c_H$$
$$= \left(\frac{1}{2}p - \frac{1}{2}\alpha p + 1 - \alpha - p + \alpha p - p^2 + \alpha p^2 - 1\frac{1}{2}p + 1\frac{1}{2}p^2 + 1\frac{1}{2}\alpha p - 1\frac{1}{2}\alpha p^2\right.$$
$$\left. - 1 + 2p - p^2 + \alpha - 2\alpha p + \alpha p^2\right)\frac{1}{3}c_H = \left((\alpha-1)\frac{1}{2}p^2\right)\frac{1}{3}c_H$$

$$\frac{1}{2}p(p - \alpha p + \alpha)I_iB_i > \theta e_i + (\frac{1}{2}p^2 - \frac{1}{2}\alpha p^2)\frac{1}{3}c_L + (\frac{1}{2}\alpha p^2 - \frac{1}{2}p^2)\frac{1}{3}c_H$$
$$\frac{1}{2}p(p - \alpha p + \alpha)I_iB_i - (\frac{1}{2}\alpha p^2 - \frac{1}{2}p^2)(\frac{1}{3}c_H - \frac{1}{3}c_L) > \theta e_i$$

So, worker i with high ability, facing strategy N(e), will exert effort if:

$$\frac{1}{2}p(p - \alpha p + \alpha)B_i - (\frac{1}{2}\alpha p^2 - \frac{1}{2}p^2)(\frac{1}{3}c_H - \frac{1}{3}c_L) > \theta$$