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Abstract

The rising trend of projects with high-skilled and autonomous contributors increasingly exposes managers to the risk of idiosyncratic individual behaviors. In this paper, we examine the effects of an important behavioral factor, an individual's *cost salience*. Cost salience leads individuals to perceive the cost of immediate effort to be larger than the cost of future effort. This leads to procrastination in early stages and back-loaded effort over the course of the project. We model the problem confronting the manager of a project whose quality is adversely impacted by such distortion of individual effort over time. Complementary to prior works focused on the planning and scheduling tasks of project management in the absence of human behavior, we find that managers should reward contributions made in earlier stages of a project. Our analysis also yields interesting insights on the project team performance: teams with diverse levels of cost salience will perform better than homogeneous teams. We also address another important facet of team composition, namely the choice between *stable* and *fluid* teams, and find that the practice of creating *fluid* teams might have previously unrecognized benefits when behavioral aspects of projects are considered. We conclude with insights and organizational implications for project managers.

Keywords: Project Management; Procrastination; Cost Salience; Behavioral Operations Management

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1 Introduction

Project management is gaining importance in organizations, as projects become vital vehicles for launching new offerings, integrating newly-acquired firms, and re-engineering business processes, thereby achieving growth, organizational change/renewal and value addition. The ability to manage projects for outcome quality and on-time delivery is increasingly recognized as a critical competence for firms in an information-intensive economy requiring customized, development-intensive products and services (Peters, 1999). Even as project management becomes more important, the nature of projects and the skills required to manage them are also evolving. Hierarchical industries of the past allowed easier administration of project workers, where managers could specify, define, schedule, and control project tasks clearly.

Project managers face several new challenges that arise due to the increasing autonomy of contributors. First, much of the information about the activities and tasks is more abstract, which makes it difficult for managers to specify and require completion of certain amounts of project work by certain periods, unlike conventional settings like construction projects. Second, the increasing complexity, specialization, and improvised effort required for projects increases the power wielded by talented project professionals. This has made it harder for managers to dictate to individuals as easily as they could in a traditional hierarchical organization, and they must rely on nuanced managerial approaches and incentives. The greater flexibility and discretion wielded by individual project team members makes managers more vulnerable to the behavioral quirks and limitations of these workers.

Project performance is particularly susceptible to the *procrastinating behavior* of individual workers. This paper focuses on one particular psychological cause of procrastination in which individuals attach a greater *salience* to the present moment, amplifying the costs of immediate effort and increasing their tendency to defer work (Akerlof, 1991; O'Donoghue and Rabin, 1999). Such behavior is particularly challenging in project settings where the task requires skilled expertise, but is not sufficiently exciting to intrinsically motivate workers. Examples include information technology and business process outsourcing projects that lack the novelty of discovery-oriented projects, although they require contributions from highly skilled, autonomous workers. While hard deadlines may insure that ultimate completion itself is not delayed, procrastinating workers tend to leave a greater amount of work closer to the deadline and cram to complete the tasks. This type of *effort distortion* can result in poor performance outcomes for a project as seen in prior work (Ariely and Wertenbroch, 2002; Cadena et al., 2011) and in our own studies of industrial projects briefly discussed below.

The challenge faced by contemporary project managers is illustrated by a global provider of business process outsourcing (BPO) services, which we'll refer to as Omega. One of the main services provided by Omega's BPO group entails business plan/business case document preparation support for its clients. Omega's key objective is to maximize client satisfaction by meeting promised deadlines and delivering high quality output. When a new project arrives, the manager reviews the amount of content-creation involved in completing the project by the requested deadline, and assigns a small team of employees to work on it. Our interviews with a project manager at this company indicate that a high frequency of errors in Omega's deliveries has been associated with the tendency of workers to postpone exertion of effort during the course of the project. While project managers face other challenges such as managing technical risks in projects that are more discovery and development-oriented, a large class of projects increasingly involve delivery of services where the issue of procrastination and effort distortion significantly complicates project management. Not being able to use command-and-control methods common in more hierarchical settings, managers must refine management skills beyond offering incentives in order to reduce the adverse impact of effort distortion on quality and client satisfaction.

The majority of projects at Omega are performed by teams of young professionals, who work around the clock to meet project deadlines. While a significant portion of their remuneration is tied to the total amount of work done by an employee, the limited creativity required in document preparation projects results in cost salience, and consequently, procrastination when the deadline is farther away. Employees meet the deadline by cramming during later stages of the project resulting in mistakes (inadequately validated business cases, etc.) that may be identified by the client after significant investments resulting in a significant cost of re-directing the effort. Therefore, firms like Omega cannot ignore the consequences of cost salience, as it may result at least in a damage to their reputation and they may also be required to bear the subsequent costs of poor quality. Further, in addition to well-known delays in construction projects, procrastination due to cost salience can also result in significant costs if essential resources become unavailable or expensive (Koch, 2005).

In this paper, we seek to understand the implications of individual behavior in project management by modeling the interactions between a project manager and workers who are subject to different degrees of cost salience. Owing to the complexity of the setting, we extract some key features of the problem to obtain actionable managerial insights. To achieve this purpose, we consider a project under an externally imposed deadline (of two periods). An employee's effort during the project and the quality of output received by the manager depend on the following factors: (a) the payment in each period, (b) the assignment of workers to projects, (c) constitution of the project team with regards to the behavioral heterogeneity of the team (as measured by their salience) or the fluidity of the team (which would dictate the degree to which workers are familiar with each other's behavioral tendencies).

One of our main findings is that project payment timing must be tuned to the cost salience of individual project workers. While previous research on project payments suggests that more payments should be made in later stages in the absence of behavioral biases (e.g. Dayanand and Padman, 2001), we find that front-loading payments would be useful to motivate workers to distribute effort in a smooth manner, thereby mitigating the effects of effort distortion. In other words, front-loading payments promotes urgency in earlier stages of a product, which is required if workers have greater cost salience. The degree to which a manager intervenes and uses wages is critically dependent on the combination of the worker's cost salience and the quality cost of effort distortion in a particular project. We derive closed form results that help demarcate regions in which a manager ignores, tolerates, controls, and prevents worker effort distortion.

Second, analysis of projects with multiple contributors leads to several interesting insights regarding team constitution. Because workers in one project have to compete for greater payment from available work, their behavior is affected not only by their own cost salience but also other workers' cost salience. We find that a more diverse team (a team with greater separation in the cost salience of workers) tends to outperform a less diverse team with the same average level of cost salience. Consequently, a manager would do well to assign a more diverse team (in terms of tendency to procrastinate) to more quality-sensitive projects in their portfolio.

Third, project teams are formed in a *fluid* manner by bringing together skilled workers who are familiar with each other to varying degrees (Huckman and Staats, 2011). When paired with a co-worker that they are not acquainted with, a worker also allocates his effort over the duration of the project based on his belief about the other worker's cost salience. Our results show that this belief could be a valuable strategic instrument for the project manager in certain scenarios. In short, the manager is able to influence the beliefs — and, consequently, effort allocation — of workers by controlling the extent to which workers recognize their counterpart's cost salience. We derive more detailed conditions under which stable and fluid teams lead to better project outcomes.

To the best of our knowledge, this is one of the early efforts that explicitly incorporates behavioral biases in the study of project management decisions. Our analysis leads not only to testable hypotheses, but also to increasingly actionable managerial insights. For example, the rise of freelance project work has been accompanied by the services like elance and oDesk that help managers periodically monitor the contributions of workers (Needleman, 2010). In addition to emphasizing the need for the behavioral management of project work, these services also offer tools to implement the actions we propose.

2 Related Literature

This study adds a behavioral perspective to the planning and management of projects, and is closely linked to both the Project Management (PM) and Behavioral Operations Management (BOM) literatures. Within the PM literature, the problem of scheduling projects for on time completion and high quality execution is of huge practical importance, and has deservedly received the most theoretical attention (for a comprehensive survey of this literature, see Herroelen, 2005). This stream of research has largely focused on the technical aspects of planning and scheduling projects with rational contributors (Schonberger, 1981). However, new organizational challenges of project management, especially the need for project managers to deal with the behavioral biases of project workers have received scant attention (Krishnan and Loch, 2005; Gino and Pisano, 2008). Such behavioral issues have recently begun to attract attention in the operations management literature (e.g. Loch and Wu, 2007), especially modeling and empirical work in the domain of manufacturing and inventory management (e.g., Bendoly et al., 2006), supply chain operations (e.g., Croson and Donohue, 2006), and customer behavior in service operations and revenue management (e.g., Shen and Su, 2007).

In the project scheduling literature, the relationship between individual behavior and project outcomes was discussed by Goldratt (1997), who proposed the usage of project completion buffers as cumulative project slack to minimize project tardiness. Subsequent papers have discussed the details of this approach, as seen in the work of Herroelen and Leus (2001), who study how to set buffer size and reschedule projects under the critical chain approach. Even if project workers do not allow work to expand and fill time (Parkinson, 1958), they may procrastinate and delay the start of their activities owing to the presence of shared project slack. Once nearing completion deadline, these project team members might have to accelerate their efforts significantly (Brunnermeier et al., 2009), which could lead them to commit errors and cut corners. The subject of individual incentives and project selection/execution have also begun to receive increasing attention in the New Product Development literature, but current studies do not yet focus on the behavioral biases of contributors (Kavadias and Sommer, 2009; Mihm, 2010). We contribute to this growing literature by studying the impact of individual behavior on project execution.

Beyond project management, there have been extensive studies on procrastination in the psychology literature (see meta-analysis in Steel, 2007). Procrastination has been found to be not only widespread in the general population (Harriott and Ferrari, 1996), but also negatively correlated with work performance, which has been consistently shown in several studies. For example, in an experimental study, Ariely and Wertenbroch (2002) found that participants performed proofreading-like tasks better (detected more errors) when their efforts were smoothed by intermediate deadlines than those who were given only an end deadline. Also, Steel's (2007) meta-analysis found consistent negative correlation between procrastination and performance in the literature. Neither procrastination as a strong behavioral regulator nor its negative impact on project output quality has, however, been explicitly taken into formal modeling consideration in project management research. While there are various causes for procrastination, we particularly focus on cost salience, and analyze a project manager's possible decisions that can influence procrastinating behavior and improve project performance.

On the modeling side, we adopt the spirit of inter-temporal time preference from economics developed at an individual unit of analysis (Akerlof, 1991; O'Donoghue and Rabin, 1999). We extend this to a project context with multiple individuals, when delay is not an option, and focus on the quality concerns of the manager. Specifically, we consider settings where project quality is associated with the pattern of temporal effort allocation by project professionals. While incentives are one aspect of our analysis, we also develop insights regarding the impact of worker assignment to projects, team composition, and information provided to project workers in a team.

We develop a model of project management with biased workers and characterize the compensation structure for a single-worker project in §3. Management of projects with multiple workers is explored in §5. In §5.2, we consider how the worker's lack of complete information about his peer's salience affects his own behavior, and identify conditions under which a project manager might use this to advantage. We conclude with the implications of our results in §6.

3 Model of a Project with Procrastinating Contributors

Cost Salience and Procrastination. We present a project setting in which a project manager must manage team members who have a tendency to procrastinate as they attach greater salience to immediate-term costs when allocating efforts over time. This aspect of cost salience can be simply illustrated in the following example adapted from Akerlof (1991). Suppose one has freedom to choose to finish a task with a benefit of v at a cost of c between an earlier time ("today") and later times. Finishing the task today brings a net payoff of only $v - \theta c$ because of the psychological salience of incurring immediate cost captured by $\theta > 1$, while the net payoff of finishing at any later dates is $v - c$. This leads to a preference for delaying work whenever possible. [1]

In the context of our project, in each period, the worker incurs a convex (marginally increasing) cost in producing an effort level e, $c(e) = \frac{e^2}{2}$. Furthermore, the worker also overvalues any effort-related cost incurred in the first period relative to the second period by a *cost-salience factor*, θ, also referred to as the worker's type. The parameter θ captures the degree of the worker's cost salience such that the early cost has a higher impact on the worker's utility when $\theta > 1$. The worker's salience factor θ can also be construed as the degree to which the worker is behaviorally biased by valuing an immediate unit of leisure time over delayed unit of leisure time.

The project environment could be characterized by heterogeneity in cost salience and uncertainty about the worker's type. Heterogeneity occurs when there are workers with different levels of θ, with lower values of θ representing greater diligence (or willingness to work sooner) on the part of the

[1] Cost salience, as described here, is a special form of dynamic inconsistency discussed in the economic literature, and is also similar to the notion of present biased preferences, in which an individual seeks immediate gratification by placing a stronger relative weight to rewards received in an earlier moment of time (O'Donoghue and Rabin, 1999).

worker. Uncertainty about worker behavior arises in organizations where workers are drawn from a shared, large pool of resources for each project; naturally, in settings where a manager repeatedly engages with a few workers who are dedicated to the manager, uncertainty about behavioral type will be a less important factor. In the interest of brevity, we present the more general model with uncertainty about worker types in §4. The situation without uncertainty is presented in more detail in Wu et al. (2012). It must be noted that in order to focus on the effect of cost salience on worker behavior, we normalize the time-discounting factor to 1; therefore, effort levels in our analysis are purely the outcome of cost salience rather than temporal discounting of costs and rewards.

Effort Distortion and Its Consequences. The project manager is responsible for the completion of a project with a fixed scope and a deadline. The scope and deadline are assumed to be fixed to keep the focus on the quality consequences of worker's cost salience. In the base case, the manager hires a project professional to complete the project, and without loss of generality, has a total of 1 unit work that must be finished by the worker in two periods. The manager faces a high penalty (∞) if the project is not completed within two periods. The end of the first period might represent a milestone planned by the project manager to track progress. The end of the second period corresponds to the completion date for the project committed to by the manager. More importantly in our model, the project manager also faces a quality cost incurred by procrastinating project workers. The quality of the project depends on the effort level of workers in the two periods. When more work is left to be done in a later period than what is completed in an earlier period, the exertion of effort is *distorted* over the duration of the project. Such a distortion lowers the overall quality of the project. This connection between procrastination and performance has been observed in a number of contexts in prior studies (Ariely and Wertenbroch, 2002; Steel, 2007; Cadena et al., 2011).

The consequences of poor performance often become observable only after the project is completed and the project manager is held to account for remedying quality issues that surface later. In our industrial project examples, for instance, software and IT service delivery companies are asked to commit to fix all the quality problems that emerge from their delivery for a period of time beyond their delivery date. In a simple and intuitive manner, we model the effect of procrastination by the worker(s) as an indirect remedial cost paid by the manager that is increasing in the amount of distortion. Specifically, we adapt a quadratic form, which is common in project management and product development to model the cost of effort (see for example, Bhaskaran and Krishnan 2009). If the amounts of completed work in the two periods are e_1 and e_2, the manager incurs a cost of quality loss of $\kappa\left(\max\left\{e_2 - e_1, 0\right\}\right)^2$, where $\kappa \geq 0$ represents the manager's cost of subsequent remedial actions to address quality issues resulting from effort distortion. Note here the quality loss only occurs when the effort distortion leads to more work to be finished by the deadline, and more work in the late stage does not improve the quality caused by the less work in the early stage. In projects with multiple stages, the work in later stages is not just a repetition of that in earlier stages, and therefore may not strengthen the quality with more work. For example, consider projects that involve creation of presentations for overseas clients, which is an important component of Omega's business. Earlier stages of the such projects involve careful understanding of a client's requirements, while later stages involve execution to the template created. Errors accumulated due to effort distortion in one part of these projects such as in requirements definition) cannot be overcome easily with greater effort in other parts. Therefore, while time lost in one stage can be reclaimed by crashing another stage, quality lost in one stage cannot entirely be compensated with gains in another stage. In fact, cost of making the changes after completion/launch are usually substantially higher due to the greater coordination and disruption entailed. This is also true in general of many projects in many industries such as software development, custom manufacturing (across tasks) and many creative services (for example, advertisement campaigns).

It is important to note that the firms in different industries may face very different levels and kinds of costs owing to effort distortion. A business process outsourcing services firm, such as Omega discussed earlier, faces both internal and external costs if the outcomes are of poor quality: additional internal resources have to be redeployed to fix these quality issues after the project is delivered, and the firm also faces high costs of customer dissatisfaction and future customer acquisition if issues are discovered after delivery due to effort distortion by its employees.[2]

Compensation Scheme. As in our motivating examples, we assume that the knowledge of specific activities is privately known to the project professional, which offers the worker sufficient autonomy of managing the pace of execution. As a result, work division over the course of the project (i.e.,

[2]In our model, we assume that the quality cost is borne by the manager and not shared by the workers. This can be justified as follows: (1) the external cost in terms of customer satisfaction and acquisition cannot be directly specified to the workers (2) the quality cost can also be seen as expected loss in the sense that the more effort distortion, the more likely quality problems arise after delivery, which also makes quality cost not contractible to the workers.

how much work to complete in each period) is not contractible upfront by the manager. Even if the manager may have some idea of the job, she may not want to contractually stipulate upfront the work division during the project. Research in psychology, termed self-determination research, shows that offering workers sufficient discretion over the planning and execution of tasks serves to boost their intrinsic motivation and performance (Deci and Ryan, 2002). The effort invested by a worker, however, is assumed to be observable ex post. For example, the manager in the BPO firm can check how much documentation has been finished by the worker, even though she cannot demand the amount of work to be finished by a certain point of time. Such an ex-ante non-contractible but ex-post observable nature of work has been considered by several other researchers in the economics literature dealing with contract theory, as reviewed comprehensively by Tirole (1988).[3]

The manager offers workers incentives to induce improved performance. A linear incentive (or wage rate) compensation scheme is chosen in our analysis for its wide applications in businesses (Holmstrom and Milgrom, 1987). Wage rate compensation is commonly used in managing knowledge-intensive projects. Examples include hourly rate for programmers and for management consultants. While constant wage rate throughout the project is the common practice, we are not restricted to such scheme that is shown later in the analysis not always optimal for the manager. It is also appropriate to note at this point that while the effort is observable only at the end of a period, we do not consider any unobservable uncertainty in the process. While this sounds restrictive, this is justifiable in a vast majority of execution-intensive projects that do not involve highly creative or risky tasks. Further, we make this assumption to expressly focus on an important behavioral issue that arises even when it is not compounded with exogenous uncertainties.

The rigid deadline for the project requires the manager to offer a wage rate plan over two periods (w_1, w_2), such that the worker participates and finishes the project $(e_1 + e_2 = 1)$. Here we assume that one unit effort translates into one unit finished work, and effort and work are used interchangeable. Upon finishing the project, the worker receives total payment of $w_1e_1 + w_2e_2$ from

[3]In particular, in our model, the project manager delegates the whole project to the worker. However, the project manager is not able to contract on a detailed plan to carry out the project across stages. For example, in business case document preparation projects, while the project manager engages the worker to finish the whole project, the tasks in a project can vary substantially across projects and are not standardized as in typical production lines. Therefore, it becomes too time/cost consuming for the project manager in each project to specify exactly how much to finish in each stage ex-ante because the work required can be very task-specific. When the project is finished and output is fully observable, however, it will become easy to evaluate how much has been done in each stage. The real challenge in managing such projects is that the project manager can only contract the whole project to the worker to a degree beyond which the project manager is not able demand more detailed execution.

the manager.[4] Since the total amount of work is fixed, the manager's objective is to induce an execution plan (e_1, e_2) that minimizes the sum of direct (compensation) and indirect costs (quality cost) of completing the project. The manager's total cost is given by

$$\mathcal{C}_P = \kappa \left(\max\left\{e_2 - e_1, 0\right\}\right)^2 + w_1 e_1 + w_2 e_2, \tag{1}$$

In the rest of the paper, we investigate how the manager can elicit the appropriate amount of effort from workers to minimize the total cost of executing the project. Although our primary interest is in managing procrastination in an interpersonal context, we begin by analyzing a simpler setting with a single agent. This allows us to develop some structural insights regarding the compensation that is required to minimize procrastination, which we build on in §5.

4 Managing A Project with a Single Worker

4.1 Optimal Effort Levels for Worker

We first present the worker's problem of effort allocation over the two periods. Depending on the salience parameter θ and wage rates (w_1, w_2), the worker would allocate effort levels e_1 and e_2 over the course of the project. Objectively, the total cost incurred by the worker is only $(e_1^2+e_2^2)/2$. However, due to cost salience, the worker perceives the overall utility at the beginning of the project to be

$$U_{A1} = w_1 e_1 - \theta \frac{e_1^2}{2} + w_2 e_2 - \frac{e_2^2}{2}. \tag{2}$$

We will assume that the wages are such that the agent has an incentive to complete the project; we show later that this must be true as long as the manager faces a severe penalty for incompletion or tardiness. The worker maximizes expected utility U_{A1} by choosing an effort allocation to finish the

[4] The manager's linear incentive contract may also include a fixed component, which is normalized to be zero. If the fixed component is included in the compensation scheme, the optimal value of it is always negative because the fixed component serves as a rent extraction instrument. The negative fixed component suggests that the project manager charges the worker for working on a project, which is not practical. Furthermore, the effort allocation is determined only by the wage rates in the two periods. For simplicity, we also assume that in the worker participation constraint the outside option has zero value.

project, i.e. $e_1 + e_2 = 1$. This results in optimal effort levels e_1^* and e_2^*, which are given by

$$e_1^* = \frac{1 + w_1 - w_2}{1 + \theta}, \qquad e_2^* = \frac{\theta - w_1 + w_2}{1 + \theta}. \tag{3}$$

It is easy to observe that the effort in any given period increases with the wage rate for that period and decreases with the wage rate for the other period. More importantly, for any given incentive structure, the first period effort e_1^* decreases with θ, while the second period effort e_2^* increases with θ. As a special case consider a project where $w_1 = w_2$. Cost salience results in a difference between efforts in the two periods given by $e_2^* - e_1^* = {}^{(\theta-1)}/_{(\theta+1)}$. This effort distortion and its quality consequences are of central importance when the manager designs a contract for the worker.

4.2 Optimal Contract for Manager

In this section, we analyze the optimal contract set by the manager who employs the worker described above. The manager would like to tailor a contract specifically for the hired agent's cost-salience. Under many circumstances, however, the manager might not be able to tell a worker's type with certainty. For example, the worker is a new hire and has not worked with the project manager very often. In this section, we investigate how optimal wages are affected by the uncertainty regarding the worker's type.[5]

We assume there are two types of workers: the high type (H-type) with θ_H and the low type (L-type) with θ_L, such that $\theta_H \geq \theta_L \geq 1$. While the type is known to the individual worker, the manager only knows that the probability of a L-type or H-type worker is p and $1 - p$, $0 < p < 1$. The manager offers a common wage scheme acceptable to both types.[6] The manager's problem is

[5] In the interest of brevity, analysis for the case in which the worker's type is known is presented in the companion paper in Wu et al. (2012).

[6] While we focus on this *pooling* contract, the manager may also consider a *separating* wage scheme that is only acceptable to the worker of θ_L (i.e., shutting down the H-type worker). However, in our setting, the manager's objective is to minimize the total cost of completing the project, and not completing the project is not an option. Therefore, screening is not considered.

given as follows:

$$
\begin{aligned}
\min_{w_1,w_2\geq 0} \quad & \Big\{p\left(w_1e_{L1}+w_2e_{L2}+\kappa\left(\max\left\{e_{L2}-e_{L1},0\right\}\right)^2\right)+ \\
& (1-p)\left(w_1e_{H1}+w_2e_{H2}+\kappa\left(\max\left\{e_{H2}-e_{H1},0\right\}\right)^2\right)\Big\} \\
s.t. \quad & U_{i1}=w_1e_{i1}-\theta_i\tfrac{e_{i1}^2}{2}+w_2e_{i2}-\tfrac{e_{i2}^2}{2} \qquad \geq 0 \quad i=L,H \quad (IR1) \\
& U_{i2}=w_2e_{i2}-\tfrac{e_{i2}^2}{2} \qquad \geq 0 \quad i=L,H \quad (IR2) \\
& \{e_{i1},e_{i2}\}:=\text{argmax}_{\tilde{e}_{i1},\tilde{e}_{i2}}U_{i1}\left(e_{i1},e_{i2}\right) \qquad (IC) \\
& s.t.\;\; e_{i1}+e_{i2} \qquad =1
\end{aligned}
\tag{4}
$$

The manager's objective in Problem 4 is to minimize the sum of expected costs arising from direct expenses in wages and indirect expenses due to effort distortion. Adhering to the individual rationality constraint *IR1* ensures that agents of both types have an incentive to accept the contract and start the project, while *IR2* ensures that the project is completed regardless of the type of the agent. Finally, the incentive compatibility constraint *IC* accounts for the worker's self-interested effort allocation once they observe the wages set by the manager (from equation 3 above). In Lemma 1 below, we present the optimal contract for the manager depending on the quality cost parameter κ. All proofs, unless otherwise mentioned, are provided in the Appendix.

Lemma 1. Optimal Wage Structure for a Single Worker Project.
For a project with a single worker whose type is unknown to the manager, the optimal wage rates are as follows. There exist thresholds κ_1 and κ_2 such that

$$
\begin{aligned}
w_1^* &= \tfrac{\theta_H}{2(1+\theta_H)}, w_2^* = \tfrac{\theta_H}{2(1+\theta_H)}, && \text{if} \quad 0\leq\kappa\leq\kappa_1 \\
w_1^* &= \omega_1, w_2^* = \tfrac{\theta_H-\omega_1}{1+2\theta_H}, && \text{if} \quad \kappa_1<\kappa\leq\kappa_2 \\
w_1^* &= \omega_2, w_2^* = \tfrac{\theta_H-\omega_2}{1+2\theta_H}, && \text{if} \quad \kappa>\kappa_2
\end{aligned}
$$

Furthermore, the optimal wage rates are such that $w_1^*\geq w_2^*$ for all $\kappa\geq 0$.

While the unknown worker type results in more scenarios of optimal wage rates, the structure remains the same, that is, the manager should offer higher wage in the early stage. However, the more complex wage scheme induces certain outcomes that are infeasible in the known worker type case. Recall that when the manager knows the worker's type, the optimal wages always induce effort distortion. In the presence of uncertainty about type, however, the optimal wages eliminate effort distortion for the L-type worker when the quality cost is high $\kappa > \kappa_2$, that is, $e_{L1} > e_{L2}$. This is due to the high wage rates offered to ensure the participation of the H-type worker.

In Proposition 1 below, we consider the impact of uncertainty on the design of incentives. Let (w_1^L, w_2^L) be the optimal wages for the L-type worker, and (w_1^H, w_2^H) be the optimal wages for the H-type worker when the type is perfectly known to the manager. These wages can be directly derived by replacing θ with θ_L and θ_H in the optimal wage rates in Lemma 1.

Proposition 1. The Effects of Unknown Worker Type

(a) The first (second) period wage rate $w_1^*(w_2^*)$ decreases (increases) in p, the probability of a worker being L-type. The manager's total cost under the optimal incentive wages is non-increasing in p when $\kappa \leq \kappa_2$. The utility functions of both types under the optimal wages are non-increasing in p.

(b) Compared with the wage rates to the H-type worker when the type is known, the optimal wages for a worker with unknown type are such that $w_1^* < w_1^H$, $w_2^* > w_2^H$. Compared with the wage rates to the L-type worker when the type is known, the optimal wages for a worker with unknown type are such that $w_1^* > w_1^L$ when $\kappa \geq \max\left\{\frac{2\theta_L\theta_H+\theta_L-\theta_H-2}{8(1+\theta_H)}, \kappa_1\right\}$, and $w_2^* > w_2^L$ when $\kappa \leq \max\left\{\frac{3(\theta_H-\theta_L)}{8\theta_L-4}, \kappa_2\right\}$.

Proposition 1(a) illustrates the impact of p on wages on costs. Intuitively, a higher chance of hiring a L-type worker leads to a lower first period wage rate. The project manager can also achieve a lower cost when the chance is higher. When the quality cost is very high ($\kappa > \kappa_2$), however, the manager's cost may go up as p increases. The reason is that within that high quality cost region, the L-type worker, if hired, finishes more work in the first period, and as a result, the manager pays too much for the L-type worker. When the hired worker is more likely to be an L-type (higher p), both types' utilities decrease because the manager offers lower first period wage which mainly determines the overall utility. Furthermore, compared with the case wherein the worker is a known H-type,the first period wage becomes smaller and the second period wage becomes larger. This systematic change is driven by the fact that the manager can achieve a lower cost in case the worker is an L-type who is willing to accept a lower first period wage. At the same time, the manager needs to increase the second period wage in order to ensure the worker participates in case he is an H-type. Part (b) also suggests that the L-type worker benefits from the manager's imperfect knowledge. When $\max\left\{\frac{2\theta_L\theta_H+\theta_L-\theta_H-2}{8(1+\theta_H)}, \kappa_1\right\} \leq \kappa \leq \max\left\{\frac{3(\theta_H-\theta_L)}{8\theta_L-4}, \kappa_2\right\}$, the L-type worker receives higher wage rates in both periods than when the manager knows his type.

5 Managing Projects with a Team of Workers

We now turn to the case in which the manager can enlist multiple workers, which can potentially lower the overall cost of the project. Our focus is to understand how the number of contributors and the composition of a team can influence effort distortion in execution (and thereby reduce the cost associated with managing it). We study two important aspects of team composition: (i) behavioral diversity and (ii) team stability. The manager can control the behavioral diversity of the team by selecting the extent to which workers differ from each other in terms of their cost salience. In §5.1, we derive the optimal compensation package for teams as a function of their diversity. Further, the manager can make teams more stable by retaining prior project teams, or make them fluid by reconstituting them for a project (Huckman and Staats, 2011). In §5.2, we consider whether teams should be fluid or stable for projects that are susceptible to behavioral factors.

In order to obtain some fundamental insights regarding the management of effort distortion in projects with multiple workers, we confine ourselves to teams comprised of two workers. Projects with multiple contributors are subject to individual behaviors of two kinds from which single contributor endeavors are exempt. Individuals could vie to complete a greater share of the project if they are motivated monetarily, or free-ride on their partner's effort if their contributions cannot be observed at an individual level. In our model, even though the manager cannot specify the work division between the two period upfront, he can observe the exact amount of contributions made by a worker in each period ex post, and therefore the focus is on managing — and if possible utilizing — the heterogeneity among workers.

5.1 Managing Stable Teams

The manager sets the same wage rates w_1, w_2 for the two workers with salience levels θ_L and θ_H ($\theta_H \geq \theta_L \geq 1$), respectively. The two workers simultaneously and independently set effort levels e_{it} in order to maximize their own overall net utilities subject to the available amount of work:

$$U_i = w_1 e_{i1} - \theta_i \frac{e_{i1}^2}{2} + w_2 e_{i2} - \frac{e_{i2}^2}{2},\ i \in \{L, H\}. \tag{5}$$

The cost minimization problem faced by the manager engaging two workers is given below.

$$
\begin{array}{lll}
\min\limits_{\{w_1,w_2\geq 0\}} & \mathcal{C}_P=\kappa\left(\max\left\{e_{L2}+e_{H2}-e_{L1}-e_{H1},0\right\}\right)^2 & \\
& +w_1\left(e_{L1}+e_{H1}\right)+w_2\left(e_{L2}+e_{H2}\right) & \\
\text{s.t.} & U_{i1}=w_1e_{i1}-\theta_i\frac{e_{i1}^2}{2}+w_2e_{i2}-\frac{e_{i2}^2}{2} \geq 0 \quad i=L,H & \text{(IR1)} \\
& U_{i2}=w_2e_{i2}-\frac{e_{i2}^2}{2} \geq 0 \quad i=L,H & \text{(IR2)} \\
(e_{i1},e_{i2})= & \arg\max_{(\tilde{e}_{i1},\tilde{e}_{i2})} U_{i1}=w_1\tilde{e}_{i1}-\theta_i\frac{\tilde{e}_{i1}^2}{2}+w_2\tilde{e}_{i2}-\frac{\tilde{e}_{i2}^2}{2} \quad i=L,H & \text{(IC)} \\
\text{s.t.} & \tilde{e}_{L2}+\tilde{e}_{H2}+\tilde{e}_{L1}+\tilde{e}_{H1}=1 &
\end{array}
\tag{6}
$$

The overall problem is a two-stage sequential game with a simultaneous game between the workers in the second stage, unfolding as follows: (i) first, the manager sets common wage rates for the two periods, (ii) the workers then set effort levels (e_{i1},e_{i2}), $i=L,H$, over two periods, individually taking into consideration that the project has to be finished in order for them to receive a payment in the second period.

The strategic interaction between the two workers in our model takes place exclusively through the IC constraint in Problem 6 above. Yet this is a crucial determinant of worker behavior and, as we shall see, the optimal compensation structure set by the manager. Since the total amount of work required to complete the project is limited, the workers also implicitly compete with each other for the work available in the sense that each worker's share of work is determined not only by his own cost salience but also by the other worker's cost salience. In other words, a worker's salience has significant impact on the effort choice of the other worker, and vice versa. Constraint IC insures that the combination of e_{i1} and e_{i2} chosen by worker i maximizes his net utility at the beginning of the project. It represents a simultaneous game between the two workers: when choosing their effort allocation overtime (e_{i1},e_{i2}), each worker is aware that his effort choices are bounded by the total amount of work that remains after the other worker's effort choices are made, i.e. $e_{i1}+e_{i2}=1-e_{j1}-e_{j2}$, $i\neq j$.[7] The optimal wages and effort levels are derived by backward induction, and provided in Lemma 2.

Lemma 2. Wages and Efforts with Two Agents

[7] An alternative model in which two workers sequentially compete for work at the start of each period leads to the same qualitative insights. Thus, the way the workers compete for the amount of work does not alter our results regarding the effects of cost salience. The analysis of the alternative model is available upon request from the authors.

If $\kappa < \frac{\theta_L+\theta_H+2\theta_L\theta_H}{16(2\theta_L\theta_H-\theta_L-\theta_H)}$*, the optimal wage rates are* $w_1^* = w_2^* = \frac{\theta_L\theta_H}{2(\theta_L+\theta_H+2\theta_L\theta_H)}$*, and induced first period efforts are* $e_{L1}^* = \frac{\theta_H}{\theta_L+\theta_H+2\theta_L\theta_H}$*,* $e_{H1}^* = \frac{\theta_L}{\theta_L+\theta_H+2\theta_L\theta_H}$*;*

If $\kappa \geq \frac{\theta_L+\theta_H+2\theta_L\theta_H}{16(2\theta_L\theta_H-\theta_L-\theta_H)}$*, the optimal wage rates are* $w_1^* = \frac{(4\theta_L\theta_H-\theta_L-\theta_H)(1+16\kappa)}{16(2\theta_L\theta_H+(1+8\kappa)(\theta_L+\theta_H))}$*,* $w_2^* = \frac{8\theta_L\theta_H+(1+16\kappa)(\theta_L+\theta_H)}{16(2\theta_L\theta_H+(1+8\kappa)(\theta_L+\theta_H))}$*, and the induced first period efforts are* $e_{L1}^* = \frac{\theta_H(3+16\kappa)}{4(2\theta_L\theta_H+(1+8\kappa)(\theta_L+\theta_H))}$*,* $e_{H1}^* = \frac{\theta_L(3+16\kappa)}{4(2\theta_L\theta_H+(1+8\kappa)(\theta_L+\theta_H))}$*.*

Furthermore, the wage rates are such that $w_1^* \geq w_2^*$*.*

Lemma 2 is an extension of Lemma 1 to the team projects. Once again, we find that the manager does not offer differentiated wages to correct effort distortion unless the quality cost parameter is high. When κ is less than the threshold, offering higher wages is less attractive than absorbing the quality cost from the distortion of workers' efforts. The manager's decision to intervene by setting different wages can also be explained in terms of the levels of salience parameters. As Figure 1 shows, the manager sets $w_1^* > w_2^*$ only if θ_L and θ_H are significant. If they are small ($\theta_L = \theta_H = 1$, for example), the manager is relatively unconcerned about the amount of effort distortion caused, and sets $w_1^* = w_2^*$. It is also worth noting that for some intermediate values ($\theta_L = \theta_H = 1.5$, for example), the manager would differentiate wages only if $\kappa = .5$ and not if $\kappa = .25$.

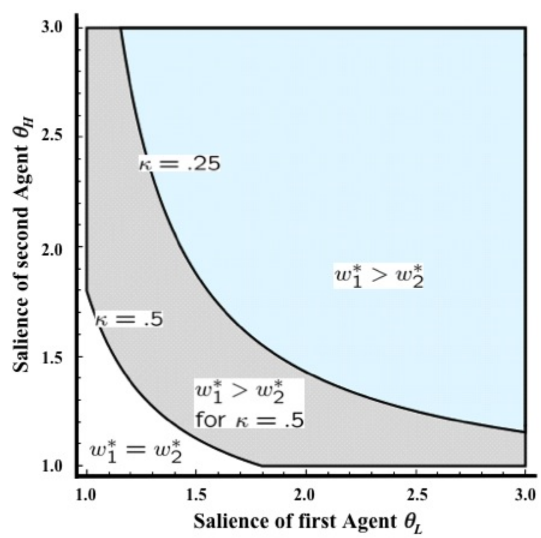

Figure 1: Optimal Wages as a Function of Cost Salience

In the following proposition, we also examine the effects of salience parameters on optimal wage structure, effort allocation, and each actor's welfare.

Proposition 2. The Effects of Salience on Stable Teams

(a) The optimal wage rates (w_1^*, w_2^*) *in both periods increase in the salience factor of each worker,*

θ_L and θ_H; The first (second) period wage rate $w_1^*(w_2^*)$ increases (decreases) in the quality cost parameter, κ.

(b) The first period effort level of a worker e_{i1}^* decreases in his own salience θ_i, and increases in the salience of the other worker θ_j.

(c) Worker i's utility function under the optimal wages increases in κ, and in his own salience when $\theta_i < \frac{\theta_j\left(1+2\theta_j+8\kappa(3+10\theta_j)+128\kappa^2(1+2\theta_j)\right)}{(1+8\kappa+2\theta_j)((32\kappa-2)-1-16\kappa)}$ and decreases otherwise; moreover, worker i's utility function under the optimal incentive contract increases in the other worker's salience θ_j.

Proposition 2 provides some interesting insights regarding the effects of one worker's salience on the other's welfare. A worker benefits by being paired with someone with a high level of cost salience (part c). This benefit comes from the following two compounding effects. First, a worker can get to more work because the other worker with higher cost salience tends to work less in the first period (part b); Second, the wage rates are increased by the manager to guarantee the participation of the worker with higher cost salience. Combining these two positive effects, the higher the other's cost salience, the more a worker benefits from it.

Is Diversity More Efficient?

Here we consider whether the manager should hire two behaviorally similar workers or hire two workers with very different salience levels. Suppose that the average cost salience level is $\bar{\theta}$, and the *degree of diversity* by δ such that a two-worker team has salience parameters $(\bar{\theta}-\delta, \bar{\theta}+\delta)$. Thus, a larger δ implies that the two workers are more diverse, while preserving the average salience level of the pair at $\bar{\theta}$. The question then becomes whether the manager prefers a more diverse team of workers or a more homogeneous team. This question can also be asked from a different angle in that the manager needs to choose a two-worker team with different salience parameters (θ_L, θ_H) or with the same salience (θ, θ) (i.e. two workers have the same type θ). The following proposition provides answers to this question.

Proposition 3. The Effect of Diversity

(a) The manager's overall cost decreases in the diversity measure δ. Moreover, a larger diversity (higher δ) leads to lower effort distortion.

(b) The manager's overall cost is lower for a diverse team (θ_L, θ_H) than for the homogeneous team

(θ,θ) if $\theta > \frac{2\theta_L\theta_H}{\theta_L+\theta_H}$; Moreover, when $\theta > \frac{2\theta_L\theta_H}{\theta_L+\theta_H}$, the diverse team creates smaller effort distortion.

Proposition 3(a) also implies that a diverse team outperforms a homogeneous team with averaged salience (i.e. $\delta = 0$). When a team's salience levels diverge, the cost saved from the worker with lower salience $(\theta - \delta)$ in terms of completing more work in the first period outweighs the loss in terms of higher wage rates caused by the worker with higher salience $(\theta + \delta)$. Therefore, overall performance improves as the team becomes more diverse. Par(b) compares diversity and homogeneity from a more general perspective. Note that the threshold above has the property that $\theta_L \leq \frac{2\theta_L\theta_H}{\theta_L+\theta_H} \leq \frac{\theta_L+\theta_H}{2}$. This implies that the two workers in the homogeneous team are more cost-efficient to the manager only when the salience is low, $\theta < \frac{2\theta_L\theta_H}{\theta_L+\theta_H}$.

The analysis of diversity in project teams has implications for assignment rules for multiple projects. When the manager has two projects $(\kappa_H > \kappa_L)$, and two teams, one diverse team $(\bar{\theta} - \delta, \bar{\theta} + \delta)$ and one homogeneous team $(\bar{\theta}, \bar{\theta})$, he should assign the diverse team to the more quality sensitive project (κ_H). Therefore, behavioral diversity is more valuable in teams that work on projects whose outcomes are more sensitive to effort distortion.

5.2 Managing Fluid Teams

Quite often, individuals with varying backgrounds and exposure are brought together to work on a project. In such *fluid* teams, workers might not have perfect knowledge of each other's salience (Huckman and Staats, 2011). While this is more common in some industrial settings than others, the wisdom of creating new groups, at the cost of breaking existing ones, is debatable (Edmondson and Nembhard, 2009). In this section, we explore the usefulness of new group creation through the lens of effort distortion. We make a natural and intuitive assumption that in new groups, individuals do not have perfect information about the behavioral attributes of their cohorts. In our model, this is manifested as worker i's lack of perfect information about θ_j $(j \neq i)$. The manager of the project, however, is well aware of each worker's salience parameter because of repeated interactions with the employee over several projects (Baker, 2008).

There are two types of workers in the workforce: the high type (H-type) worker with salience factor θ_H and the low type (L-type) worker with salience factor θ_L such that $\theta_H \geq \theta_L \geq 1$. The probability that a worker is an L-type or H-type is p and $1 - p$ respectively, and this probability is common knowledge to all workers. Probability p can also be taken as the fraction of workers that has salience θ_L. The manager, as before, sets wage rates w_1 and w_2 for the two periods, and these rates are common for the two workers. A worker of type i knows that the total amount of work that he can get is either $1 - e_{L1} - e_{L2}$ with probability p or $1 - e_{H1} - e_{H2}$ with probability $1 - p$, where e_{Lt} and e_{Ht} $(t = 1, 2)$ are the effort levels of the other worker depending on whether his salience is θ_L or θ_H, respectively. Note that workers rely exclusively on their own salience in making effort decisions, and do not have more than the distributional information about their co-worker. Based on his own type, each worker picks the effort level in the first period to maximize his net *expected* utility from the project. The utility maximization problem faced by a type i worker, for given w_1 and w_2, is given below.

$$\max_{e_{i1}, e_{i2}} \mathbf{E}[U_i] = w_1 e_{i1} - \theta_i \frac{e_{i1}^2}{2} + w_2 \left(p e_{i2}^L + (1-p) e_{i2}^H\right) - \frac{p \left(e_{i2}^L\right)^2 + (1-p)\left(e_{i2}^H\right)^2}{2} \tag{7}$$

where e_{i2}^L and e_{i2}^H represent the amount of work the worker would do in the second period if his co-worker belongs to the L and H type respectively. Workers simultaneously decide their effort levels, and we determine the effort levels chosen by each type of worker in equilibrium. The optimal wages and equilibrium efforts of a team of imperfectly informed workers are shown in the following lemma.

Lemma 3. *There exists $\hat{\kappa}$ such that for $\kappa > \hat{\kappa}$, the optimal wages for an (L, H) team when both workers are uninformed of each other's type are given by*

$$\begin{aligned} w_1^* &= \frac{(1+16\kappa)\left(4\theta_L\theta_H + 2\left(p\theta_L + (1-p)\theta_H\right) - \theta_H - \theta_L - 1\right)}{16\left(1 + 8\kappa + 2\theta_L\theta_H + (2+8\kappa)(\theta_L + \theta_H) - p\theta_L - (1-p)\theta_H\right)}, \\ w_2^* &= \frac{(1+16\kappa)(\theta_L + \theta_H + 1) + 8\theta_L\theta_H + 4\left(p\theta_H + (1-p)\theta_L\right)}{16\left(1 + 8\kappa + 2\theta_L\theta_H + (2+8\kappa)(\theta_L + \theta_H) - p\theta_L - (1-p)\theta_H\right)}; \end{aligned} \tag{8}$$

The equilibrium efforts of the workers in the first period are

$$\begin{aligned} e_{L1}^* &= \frac{(3+16\kappa)(1+2\theta_H)}{8\left(1 + 8\kappa + 2\theta_L\theta_H + (2+8\kappa)(\theta_L + \theta_H) - p\theta_L - (1-p)\theta_H\right)}, \\ e_{H1}^* &= \frac{(3+16\kappa)(1+2\theta_L)}{8\left(1 + 8\kappa + 2\theta_L\theta_H + (2+8\kappa)(\theta_L + \theta_H) - p\theta_L - (1-p)\theta_H\right)}. \end{aligned} \tag{9}$$

The lemma presents the optimal wages and equilibrium efforts for a diverse team, but the expressions can be obtained for a homogeneous team by setting $\theta_L = \theta_H$.[8] The expressions lead to some interesting insights regarding the effects of information availability on effort distortion.

Proposition 4. The Effects of Salience on Fluid Teams

(a) The first period effort level of a worker decreases in his own salience, and increases in the salience of the other worker: e^*_{L1} (e^*_{H1}) *decreases with* θ_L (θ_H) *and increases in* θ_H (θ_L).

(b) Regardless of their type, the effort level of a worker decreases with p *(the proportion of L-type workers):* $\frac{\partial e^*_{i1}}{\partial p} < 0$ *for both types* $i \in \{L, H\}$

(c) The optimal wage rates increase in p*; the degree of effort distortion also increases in* p *and therefore the manager incurs a higher cost if* p *becomes larger.*

From Proposition 2 earlier, we know that when both workers have perfect information about the participants, a worker's first period effort decreases with his own salience and increases in his counterpart's salience. Does this insight extend to the situation in which there is imperfect information? Interestingly, Proposition 4 (part a) confirms that each worker, regardless of his counterpart's type, performs less work in the first period if his own cost salience is higher, and each worker can take more work in the first period if his co-worker's salience is higher. Note that this response to salience holds even though workers are not aware that they are members of a diverse team and the value of probability p does not affect this property.

In part (b) and (c) we observe the effect of the imperfect information represented by p on the manager's cost. When a worker expects his co-worker to be more likely an H-type (smaller p), we see that the worker expects his co-worker to do less work in the first period and increases the amount of work he completes in the first period. Indeed, this serves to *compensate* for his co-worker's increased salience in the first period. To understand why this occurs, let us suppose worker i does not alter his first period effort plan in response to an increase in $\bar{\theta}_j$, the expected cost salience of his partner $\left(\bar{\theta}_j = p\theta_L + (1-p)\,\theta_H\right)$. Because of the increase in $\bar{\theta}_j$ caused by a smaller p, the worker is left with more work than he would like ideally to perform in the second period. This leads to a reduction in the overall utility for worker i; in order to spread the additional work created over both periods, worker i advances some of this to the first period.

[8]Note here $\hat{\kappa}$ is the threshold beyond which both workers' IR constraints are satisfied (similar to the ones in Lemma 1 and Lemma 3). Here we only present the results for $\kappa > \hat{\kappa}$ in order to keep our focus on the uncertainty between team members.

Counter-intuitively, note that the optimal wages and the manager's total cost *increase* with p, the proportion of the L-type workers (workers with low cost salience). This occurs because L-type workers are more productive in the first period. Therefore, if a worker believes they have been paired with an L-type co-worker with higher probability, their enthusiasm to compete for work declines in the first period. As a result, the presence of many L-type workers forces the manager to offer higher wages, and leads to higher overall costs as well.

5.3 Stable vs. Fluid Teams

In this section, we use the results above to determine the conditions under which fluid or stable team compositions lead to efficient management of worker behavior. As we show in Proposition 5, the answer depends on the the distribution of cost salience in the population of workers.

Proposition 5. Optimality of Stable and Fluid Teams

When $p < \frac{\theta_L}{\theta_L+\theta_H}$*, the manager's overall cost is lower under Fluid team composition.*

Otherwise, the manager's overall cost is lower under Stable team composition.

A worker's believe about his co-worker's type, p, is crucial to this question: when p is small, both workers expect that they are more likely to be paired with an H-type worker, and are more motivated to work in the first period (Proposition 2 (b)). As a result, when p is small, the manager can lower costs by merely letting both workers continue in their prior belief that their coworker probably has a higher cost salience. When, however, p is high (i.e. the chance of being paired with an L-type worker is high), the L-type worker has less chance of taking more work from his coworker and he works less in the first period. In this case, it is better to create stability in order to induce more work from the L-type worker in the first period.

More generally, fluid teams are more valuable for the manager when a smaller fraction of workers experience greater cost salience. Corollary 1 discusses the relationship between the value of fluidity V — the cost difference between withholding the information and revealing the information — as a function of p.

Corollary 1. Value of Team Fluidity

(a) $V(p)$ *is decreasing in* p*, the fraction of* θ_L *workers in the population*

(b) Further, $V\left(\frac{\theta_L}{\theta_L+\theta_H}\right) = 0$.

6 Discussion and Conclusion

As projects migrate from the physical to the knowledge-intensive realm, contributors increasingly work with greater flexibility and autonomy than before. In addition to the traditional focus on timeliness and costs, managers are also concerned about the behavior of the contributors that could affect the quality of the outcome. In this paper, we have developed a model of project management with behavioral considerations in which workers are hired by the manager to finish a two-period project. Workers have cost salience and tend to leave more work to the later period, which leads to a distorted effort allocation over time and potential quality problems for the project. The manager's objective is to minimize the project cost including worker compensation and effort distortion cost that is explicitly incorporated as a function of the worker's efforts.

Our analysis shows that the cost salience not only leads to effort distortion and lower product quality, but also *higher* compensation for the worker because of the manager's motivation to meet the project deadline. Furthermore, we identify conditions under which the manager should offer higher wages in the early period to mitigate the adverse effects of cost salience. Extending the analysis to include multiple workers yields valuable insights regarding the role of team composition. First, we find that competition for work between team members could mitigate the individual contributors' tendency to procrastinate. This could result in greater project quality without escalating incentives. Secondly, we show that a team of individuals with diverse behaviors can outperform a team of similar individuals. Finally, we also investigate how the emerging practice of assembling fluid teams contributes to greater quality of project outcomes. In a fluid setting, a worker's imperfect information about their co-worker's behavioral attribute is a valuable motivational tool because it accentuates the incentive to compete for work with team members in the earlier period. These insights complement recent empirical findings regarding the behavior of fluid project teams (Huckman and Staats, 2011).

Our theoretical analysis, organized around the degree of the cost salience and the sensitivity of quality relative to effort distortion, provides practical guidelines for project management from a new perspective and a set of propositions that should be validated through future empirical studies.

- **Intervention and Compensation**: Managers should ignore, tolerate, control, or prevent effort distortion by examining the cost of project quality and worker salience (Figure 1).

Accordingly, compensation should be structured as either constant payment or front-loaded payment, which is in contrast to prior findings that delaying payments would minimize project costs (Dayanand and Padman, 2001).

- **Project Assignment and Team Diversity**: When individuals are assigned to multiple projects, the less biased workers should be assigned to more quality-sensitive projects. In larger scale projects with multiple workers, diverse teams would perform better than homogeneous teams.
- **Information Management and Team Constitution**: Information asymmetry among workers can be used to the project manager's advantage. In a diverse team, the less biased worker should be informed of the type of the more biased worker, but informing the more biased worker is detrimental to the objective of motivating early efforts. Due to the effect of the worker pool on the effort of individual agents assigned to a project, the quality of the project would improve with the quality of the workforce (lower salience).

This article offers a first formal model of worker procrastination in the context of project management that explicitly incorporates project quality and its behavioral causes. The model, though stylized, allows us to examine the effects and trade-offs of a particular decision bias in different project scenarios. In this regard, this paper contributes to a recent and growing area of research on innovation which looks at the incentives of the actors involved in a more holistic manner, by including career concerns (e.g. Siemsen, 2008) or by focusing on innovation tournaments with multiple contributors participating in contests (Terwiesch and Ulrich, 2009).

We believe the insights from this paper are readily applicable to a large class of projects in which a smooth and timely execution of tasks is crucial to the final quality of the project. The assumptions we make in this paper, such as the absence of uncertainty about outcomes, make it less applicable in highly risky environments like early stage ideation. Future work should test – both theoretically and empirically – the robustness of our findings by relaxing this assumption. We hope that our study can lead to further work on studying behavioral issues in the area of project management and operations management in general.

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