Managing Uncertainty: An Experiment on Delegation and Team Selection*

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Abstract

We study how organizations use team selection and delegation of authority jointly to navigate uncertain environments. To do so, we model a managerial decision environment in which a Manager both determines the skill heterogeneity of their Workers and determines whether to retain or delegate the ability to allocate tasks. Delegation enables better-informed Workers to allocate tasks more efficiently when uncertainty is high relative to the incentive conflict between Manager and Worker. Our novel approach allows us to illustrate that this conflict is endogenously determined by the team selection decision. Experimental data support - though not globally - the direction of our theoretical hypotheses and offer insight into how and why choices deviate from expected behavior. Notably, we identify behavioral characteristics that aid decisions along each dimension. Deliberative thinking improves all decisions under low uncertainty and improves team selection regardless of the level of uncertainty. Risk tolerance improves all decisions in highly uncertain situations and helps Managers optimally delegate decision rights in all settings. The results highlight potentially costly ways in which Managers seek to simplify their decisions, but show how deliberative thinking and risk tolerance can improve performance in a complementary manner.

Keywords: managerial decisions, delegation, team selection, task allocation, decision rights.

JEL Codes: C92, D23, D83, L22, M50

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1 Introduction

Researchers have long viewed delegation of authority as a central element of organizational structure and function (Cyert and March, 1963; Galbraith, 1974; Hayek, 1945; March and Simon, 1958). Broadly, delegation can effectively improve the quality of organizational decisions by making use of specialized knowledge or skills while accounting for limited managerial attention (Dosi, Levinthal and Marengo, 2003; Harris and Raviv, 2002; Jensen and Meckling, 1976, 1992). Delegation also helps organizations efficiently navigate changing environmental conditions (Bloom, Sadun and Van Reenen, 2010; Mendelson, 2000; Rantakari, 2008; Siggelkow and Levinthal, 2003), which Williamson (1985) defines as "parametric uncertainty" and we refer to as environmental uncertainty. Galbraith (1974) notes that such uncertainty limits an organization's ability to plan ahead, and delegation may offer crucial flexibility in adapting to changes, though at the potential cost of creating conflict between workers.

The degree of this struggle often depends on the specialization of team members (Becker and Murphy, 1992; Brandon and Hollingshead, 2004), which may also be determined by the manager. In choosing their team composition, then, managers must determine whether broadly skilled or highly specialized team members will most effectively complete their anticipated tasks. There are potential problems behind each option. On one hand, specialized units may have such difficulty in completing joint tasks that collaborative incentives fail to efficiently resolve such problems (Kretschmer and Puranam, 2008). On the other, divisions with overly similar workers may struggle with how to divide tasks due to skill overlap.

In this paper, we study how organization structure decisions (i.e. how to allocate decision rights) and personnel decisions (i.e. team selection) jointly affect managerial decisions and organizational performance in the face of environmental uncertainty. We use a transaction cost economics framework in what Puranam (2018) defines as a "micro-structural" approach, distilling the myriad complexities in organizations to focus on these two common structural elements. This novel framework allows us to explore the inter-relatedness of delegation and the degree of specialization within the organization. Specifically, we explore how a manager uses the allocation of decision rights to most efficiently complete ex-ante uncertain tasks when they also determine the degree of skill specialization, which we refer to as team selection.

Despite the potential benefit in modeling this decision environment, the interrelatedness of worker selection and allocation of decision rights is under-studied in both organizational economics and organization theory. Although these tensions have typically been studied separately, Puranam and Raveendran (2013) stress the importance of understanding them as a joint issue in organization design. While they have been explored in strategic alliances between organizations (Gulati, Wohlgezogen and Zhelyazkov, 2012), the connection is less well understood when looking within organizations. We take a first step in bridging this gap.

In doing so, we use our framework for its clear benchmark predictions rather than as a normative model. As noted by Vázquez (2004), the focus among economists on efficiency and fully rational agents has several limitations. Chief among them is the fact that people universally

fail to behave rationally. While organization theory has taken a much more diverse approach to modeling organizations (Astley and Van de Ven, 1983), a central theme has been ways in which bounded rationality impacts organizational design (Cyert and March, 1963; Galbraith, 1974; March and Simon, 1958).

Drawing on such insight, we predict that a manager's ability to tolerate risk and think deliberately will moderate their organizational structure decisions. Such individual traits are a growing focus in both organizational economics (Gibbons and Henderson, 2012) and organization theory (Powell and Colyvas, 2008). The ability of managers to weather unexpected shocks and avoid impulsive changes in response to temporary losses highlights the importance of deliberative thinking and risk tolerance; avoiding intuitively compelling - yet organizationally damaging - decisions can greatly impact both current and future organizational performance (Raveendran, 2020).

To address these aims, we develop a benchmark model in which a manager's team selection endogenizes the degree of conflict expected between workers and manager when decision rights are delegated. We then construct a laboratory experiment to shed light on how this endogenous relationship affects the use of delegation to address environmental uncertainty. [1] Furthermore, the experimental protocol enables us to control for individual risk tolerance and deliberative thinking as moderators for effective organizational design.

We find generally that participants in the manager role delegate decision rights more often as uncertainty grows. The shift toward delegation occurs gradually rather than at a specific informational threshold, as in the model. As predicted, risk tolerance moderates the ability to delegate when facing higher uncertainty. Second, we find that participants tend to underdiversify their teams relative to the benchmark predictions. Deliberative thinking shows a strong moderating effect, as participants better able to avoid impulsive choices choose team specializations much closer to the model's predictions, especially in low uncertainty environments. Combined, these results show that risk tolerance and deliberative thinking have a complementarity relationship that we did not fully anticipate in improving decisions under different levels of environmental uncertainty. Moreover, both of our moderating effects are stronger when these two decisions are made jointly.

2 Literature Review

Organizational economists typically model delegation as a tradeoff between the relative importance of informational asymmetry between manager and workers, who are better able to adapt to local conditions, and conflicts of interest, which impede collaboration.[2] The main results of

[1] Bitektine, Lucas and Schilke (2018) highlight the usefulness of controlled laboratory research for organization theory. In particular, they note how heterogeneity among a workforce can not only affect organizational outcomes, but also determine organizational structure itself.

[2] Our model and experimental environment contain interrelated elements of both cooperation and coordination. For ease of exposition, we adopt terminology from Gulati, Lawrence and Puranam (2005) and Gulati, Wohlgezogen and Zhelyazkov (2012), using "collaboration" to refer jointly to the alignment of incentives and actions.

this theoretical tension are as follows: 1) when the manager's information is poor relative to that of workers', delegating some decisions is optimal even in the face of imperfectly aligned incentives (Hayek, 1945). 2) When the consequences of incentive misalignment are paramount, a manager will benefit by retaining control of organizational decisions (Williamson, 1996). Empirically, McElheran (2014) finds that between-firm variation in decentralization is consistent with theoretical predictions based on the relative importance of adaptability or collaboration within a firm. Thomas (2010), though, finds that decentralized decisions can lead to over-specialization of product lines at the expense of firm profit.

Economists recently have focused on understanding the role of strategic communication within this environment. Theoretically, Dessein (2002) show that a manager prefers to delegate decisions rather than to communicate with a better-informed worker as long as the collaboration problem is not too large with respect to the information asymmetry. Others show that if centralized firms receive such distorted information, decentralization may be optimal even under situations with a strong need for collaboration (Alonso, Dessein and Matouschek, 2008, 2012; Rantakari, 2008). However, recent empirical studies show that such emphasis on strategic communication fails to capture behavioral responses by both managers and workers. Brandts and Cooper (2020) highlight that the collaboration problem often looms largest, and individuals struggle to interpret strategic information. Moreover, Evdokimov and Garfagnini (2019) show that laboratory participants do not behave as these models predict, mainly because they hesitate to lie strategically as much as expected. They further show that participants overweight the importance of the adaptation problem in centralized organizations and underweight it in decentralized ones.

Departing somewhat from this literature, our paper seeks to shift the focus from strategic communication to the role of team selection and its impact on the trade-off between collaboration and adaptation under environmental uncertainty. When Managers have the ability to select the specialization of their workgroup, they directly affect the degree of the collaboration problem when decision rights are delegated.

Here, we also connect with prior work in organization theory. Organization design researchers similarly view the collaboration of inter-dependent divisions and the adaptation to changing conditions as central theoretical building blocks. The typical approach holds the division of labor between tasks and individuals as a fixed and defining property of organizations (Dobrajska, Billinger and Karim, 2015; Puranam and Raveendran, 2013). Thus, research has explored collaboration and adaptation without delving into how managers take an active role in determining the degree of tension.

For instance, Siggelkow and Levinthal (2003) show that decentralized exploration in a multidivisional firm, followed by centralized reintegration, improves collaboration among divisions and improves adaptation to environmental changes. The authors analyze the cases for non-decomposable and decomposable tasks. In doing so, they leave as an open question how the level of skill specialization affects the ability to collaborate after the reintegration and how the degree of environmental uncertainty affects this ability.

Other organization design research explores incentive schemes under various degrees of organizational complexity. Kretschmer and Puranam (2008) suggest that collaborative incentives may fail to motivate collaboration among interdependent units when subunits are highly specialized. Subunit specialization, they argue, leads to differentiation in behaviors and attitudes, which could reduce organizational performance when using collaborative incentives. Dosi, Levinthal and Marengo (2003) also explore the effectiveness of various incentives as organizations face differing levels of problem complexity, implicitly keeping specialization fixed. These studies raise questions relating to team selection: What is the optimal level of specialization, and are managers able to identify it? Moreover, how might environmental uncertainty impact this decision?

We contribute to this discussion by observing how organizations deal with environmental uncertainty when managers are able to select both their team specialization and the allocation of decisions rights. Our paper fits conceptually with prior interdisciplinary research on how incentive structures and cognitition jointly impact organizations (Kaplan and Henderson, 2005) by exploring these two other critical elements of organization design. In highlighting the interrelationship between these two decisions and their impact on the collaboration/adaption trade-off, we contribute both theoretically and empirically to the work on organization design in a simple task allocation framework.

3 Theoretical Background and Hypotheses

We develop a benchmark model using agency theory (Holmstrom, 1982) that captures our theoretical hypotheses and provides greater specificity from which to measure behavioral deviations in our data. Our approach provides clear and testable predictions without having to form specific assumptions about where and how bounded rationality will affect behavior. Thus, our model serves as a benchmark from which we can clearly measure and describe deviations in behavior. Our full model can be found in Appendix A. In this section we highlight the theoretical tensions our model was designed to capture. We model how a manager adjusts both the organizational structure (allocation of decision rights) and the team composition (skill heterogeneoity) to optimally adressed environmental uncertainty.

Of course, organization theorists have long understood the role of bounded rationality in organizational function (Cyert and March, 1963; March and Simon, 1958). Boundedly rational agents may have difficulty in computing expected costs and understanding the implications of their actions. They may also react intuitively or impulsively to variance in outcomes, but it is not clear $ex - ante$ how bounded rationality should be modeled in this environment.

Accordingly, we do not expect individuals to behave strictly as predicted by our model. The assumptions of our model characterize the representative manager as a risk neutral agent with perfect ability to compute optimal choices along both the organizational structure and team composition dimensions. In other words, managers in our environment reflect carefully on both decisions simultaneously to maximize expected utility. These assumptions result in

a unique dominant strategy for each information and organizational structure condition. We can use these precise benchmark predictions to observe how certain behavioral characteristics may moderate the effect of uncertainty in organizational design. Specifically, we expect that two characteristics will have strong impacts on successful decision making in this environment: deliberative thinking and risk tolerance.

Deliberative thinking - which Stanovich and West (2000) defines as "system 2" thinking - is the use of slower, more reflective cognition requiring conscious effort and motivation to reach a decision. Prior research has shown many ways in which deliberative thinking impacts individual decision making (Frederick, 2005). Notably for our study, successful deliberation predicts more strategic behavior (Brañas-Garza, García-Muñoz and González, 2012; Kiss, Rodriguez-Lara and Rosa-García, 2016; Moxley et al., 2012) and the ability to avoid investing in financial asset bubbles (Bosch-Rosa, Meissner and Bosch-Domènech, 2018; Corgnet et al., 2014). Deliberative thinking has also been shown to help individuals use long term decision rules to avoid over-reacting to recent events (Hohnisch et al., 2016). While the ability to avoid impulsive decisions explains behavior in a wide variety of individual decisions, it has not yet been tied directly to managerial decision making. We offer a first step in this direction by studying how individuals with different cognitive reflection ability handle complex situations to determine efficient organizational structure.

Likewise, individual attitudes towards risk are intimately linked to various economic behaviors, including health outcomes (Dohmen et al., 2011), selecting into incentive contracts (Bonin et al., 2007; Grund and Sliwka, 2010), and entrepreneurship (Caliendo, Fossen and Kritikos, 2009). While entrepreneurs and managers roughly share risk preferences, they generally take more risk than the rest of the population (Brockhaus Sr, 1980; Koudstaal, Sloof and Van Praag, 2015). For these groups, risk taking is often an important determinant in firm performance (MacCrimmon and Wehrung, 1990). However, the mechanisms that connect willingness to take risk and firm success are not clear. We contribute by showing how risk tolerance may directly affect organizational structure decisions.

We can best illustrate the tradeoffs in our model by considering a simplified organization comprised of a Manager and two Workers who must complete their assigned tasks.[3] The main aim of the Manager is to efficiently allocate tasks among Workers via two "levers." First, they decide whether to retain task allocation rights or delegate this choice to the Workers. Second, they select their team by choosing whether to form a team with overlapping or more specialized Workers.

Environmental uncertainty causes information asymmetry between the Manager and Workers about the nature of the tasks. We follow the typical approach by assuming that Workers have better information than the Manager about local conditions, such as the capacity to complete a task or changes in local demand (Rantakari, 2013). The former allows Workers to better allocate tasks to adapt to the latter. When this asymmetry is higher, decentralized decision

[3]From this point, we capitalize "Manager" and "Worker" when referring to the role in our model and experiment.

making via delegation offers the most efficient solution.

In the typical transaction cost approach, Workers are assumed to minimize their effort and maximize local profits. Because of this, a Manager with high levels of uncertainty relying on better-informed Workers to allocate tasks faces a problem. Workers may not agree to allocate tasks in the most efficient way from the Manager's perspective, creating conflict between hierarchies and even between Workers. The latter is especially true when there is insufficient distinction between Worker skillsets. To the degree that such a conflict impairs the organization's function, the Manager may be reluctant to delegate.

Brandon and Hollingshead (2004) show that the ability to identify the right combination of task and team composition is fundamental to organizational efficiency. In a task allocation framework, Managers affect the degree of conflict between Workers through the selection of different specializations.[4] By the selection of Worker specialization, the Manager controls for horizontal differentiation in team knowledge. $Ex-ante$, a Worker with a particular skillset may not be better than another. Rather, efficient completion depends partly on the nature of realized tasks. This captures the idea that firms are often able to distinguish potential skill sets but it is more difficult to recognize a Worker's productivity in advance.

Given these joint tensions acting simultaneously on a Manager, their reaction along each dimension presents an opportunity for exploration. In addition to providing further theoretical and empirical findings on the organizational link between parametric uncertainty and firm structure, we address two additional questions. How does each decision impact the other, and how might their choices be driven by behavioral traits?

We begin by considering an organization that retains centralized control of decision rights. In a centralized organization, a heterogeneous team allows the Manager to better respond to a more dissimilar task profile. However, if task uncertainty is sufficiently high, the Manager may be unable to make an informed decision. The likelihood of task allocation errors therefore increases with the level of uncertainty. Figure A.2 in Appendix A illustrates this by showing the probability to reallocate task for all combinations of tasks received. It is easy to observe that, given a fixed level of team specialization, the Manager would not always change tasks where optimal (the shaded area). To minimize the $ex-ante$ impact of these mistakes, a Manager may instead prefer a team with greater overlap focused around the most common tasks (Friebel and Raith, 2010; Garicano and Santos, 2004). This leads to our first prescriptive hypothesis.

Hypothesis 1A *(H1A): In a centralized organization, the Manager should select a more heterogenous team as the level of uncertainty decreases.*

This monotonic relationship between team specialization and the level of environmental uncertainty is confirmed in our benchamrk model. However, Managers with lower deliberative thinking ability may seek to simplify the game by selecting more homogeneous teams, deviating

[4]Another way to affect successful collaboration is to clearly define Worker roles. These variables are likely to be correlated in our context, and so we assume that a more heterogenous team implies a clearer definition of roles.

more from positions predicted by the model for every level of uncertainty. This simplification arises because if a Manager selects Workers with the same level of specialization, the task allocation decision becomes irrelevant. This behavior will determine Managers' initial decisions and their subsequent adjustments. A reflective Manager will prefer a more heterogenous team in the first round and their resistance to impulse should enable them to maintain better team heterogeneity in the face of bad outcomes in the following rounds. On the contrary, a less reflective Manager reacts selecting a more homogeneous team. This gives us our first moderating hypothesis.

Hypothesis 1B *(H1B): Impulsive Managers will choose more homogeneous teams than reflective Managers for any level of information.*

In our task allocation framework, a risk averse Manager will prefer a team able to deal with the most common tasks. Therefore, they will choose a more homogenous team than predicted by the model, which may reduce their experienced volatility. In doing so, the Manager reduces not only volatility, but also the expected value of their earnings. A risk averse Manager's move away from the optimal team composition worsens expected outcomes under both centralized and decentralized structures. Thus, a risk averse Manager will be less likely than a risk tolerant one to choose a heterogeneous team composition for any level of information.

Hypothesis 1C *(H1C): Risk averse Managers will choose more homogeneous teams than risk tolerant Managers for any level of information.*

In our decentralized framework, Workers have perfect information about tasks, but a potential conflict of interest may arise between Workers and their Manager, illustrated in our benchmark model by Figure 1 in the following section. Workers with similar specializations may have difficulty agreeing on the efficient division of tasks, especially if both Workers strictly prefer the same task. These occurrences will often lead to worse outcomes for the Manager. The Manager can reduce the potential incentive conflict by selecting a more heterogeneous team, reducing the number of cases where both Workers prefer the same option, as depicted in Figure 2 in the following section. The optimal heterogeneity in skill specialization is independent of the Manager's level of uncertainty, as Workers have perfect information about realized tasks and they make the decision whether or not to reallocate between themselves. Thus,

Hypothesis 2A *(H2A): In a decentralized organization, the Manager should select a team composition independently of the level of uncertainty.*

Again, we expect deliberative thinking and risk tolerance to play moderating roles. Impulsive Managers may continue to feel temptation to reduce their team heterogeneity in response to bad outcomes (In the results, we define these "bad outcomes" more clearly in addressing the following hypotheses). Note in Figure 2 that this increases the likelihood of conflict (shown by the shaded triangular areas), which in turn makes bad outcomes more likely. To the extent that these increase as uncertainty rises, impulsive Managers will struggle to maintain consistent team heterogeneity under decentralized environments. Similarly, we expect risk averse

Managers to continue to struggle with the same issues noted under centralized control - namely, reducing team heterogeneity in response to bad outcomes to reduce perceived risk, which should correlate with the level of uncertainty. Therefore, we have the following moderating hypotheses.

Hypothesis 2B *(H2B): In a decentralized organization, impulsive Managers should be less likely to maintain consistent team heterogeneity as the level of uncertainty grows.*

Hypothesis 2C *(H2C): In a decentralized organization, risk averse Managers should be less likely to maintain consistent team heterogeneity as the level of uncertainty grows.*

We next consider the extreme cases of uncertainty. If a Manager has perfect information, they will prefer a centralized organization because the probability to make mistakes in the allocation of tasks is zero, given the team composition. On the other hand, a Manager without information in a centralized organization will select Workers who will respond better to the most common tasks, implying Workers with the same specialized knowledge will be selected. This necessarily reduces the opportunity to adapt to specific task requirements or to changing local conditions. A more efficient alternative for the Manager is to delegate task allocation rights to a more heterogeneous team, despite the potential for incentive conflict. Between these two, there must exist a threshold level of uncertainty such that the Manager will prefer a centralized organization when there is low uncertainty but a decentralized organization when the level of uncertainty increases (Dessein, 2002). Thus,

Hypothesis 3A *(H3A): A Manager should prefer a centralized organization when the level of uncertainty is sufficiently low but delegate decision rights more when uncertainty rises.*

The threshold level for each Manager may vary according to their level of deliberative thinking, risk tolerance and, in this case, also on their team selection. Experiencing more bad outcomes may lead impulsive Managers to more frequently select centralized organizational structure. This would lead to worse decisions under high uncertainty, but may help in low uncertainty environments. More reflective individuals are better able to play dominant strategies and avoid dominated strategies (Brañas-Garza, García-Muñoz and González, 2012; Kiss, Rodriguez-Lara and Rosa-García, 2016). In our framework, this suggests that reflective Managers will more frequently delegate decision rights in settings where information quality is poor, and only retain these decision rights under high levels of information quality.

Hypothesis 3B *(H3B): Impulsive Managers will be less likely to increase their use of delegation as uncertainty rises.*

A more homogeneous team increases the likelihood of bad outcomes, which may combine with the well-known result that people have an intrinsic value for control (Bartling et al., 2014; Fehr, Herz and Wilkening, 2013; Owens, Grossman and Fackler, 2014), leading risk averse Managers to select a centralized organizational structure more often than they should, particularly as their information quality worsens.

Hypothesis 3C *(H3C): Risk averse Managers will be less likely to increase their use of delegation as uncertainty rises.*

These moderating effects are likely to arise even more clearly when a Manager makes both team selection and delegation decisions jointly. Any increase in Worker heterogeneity is at odds intuitively with an ill-informed Manager opting for reduced heterogeneity as a safety measure. Ill-informed Managers may think it too risky to select more specialized teams, or to delegate task selection to Workers whose incentives may be at odds with management. Managers better able to resist such intuitive and risk averse thinking will see greater organizational performance in expectation.

4 The Experiment

4.1 Benchmark Model Framework

Consider an organization with a Manager and two Workers. Worker heterogeneity is modeled by different specializations θ_i on the interval $[0, 1]$ as in Alonso and Matouschek (2008). The Manager thus selects their team heterogeneity, (θ_1, θ_2). Once selected, each Worker independently receives a randomly drawn task, t_i^0 for $i = 1, 2$, from a uniform distribution over the same $[0, 1]$ interval.[5] Critically, Managers select their team prior to knowing the exact tasks to complete, (t_1^0, t_2^0).

Each Worker focuses exclusively on their own task and all tasks must be completed. The Manager therefore selects a team to minimize the total expected cost of the firm defined by $E[|\theta_1 – t_1^f| + |\theta_2 – t_2^f|]$, where t_i^f is the final task assigned to Worker i. In this task allocation framework, final task assignment depends on the randomly drawn tasks, i.e. $(t_1^f, t_2^f) \in \{(t_1^0, t_2^0), (t_2^0, t_1^0)\}$. The total cost to the firm increases as the distance between Workers' positions and their final assigned tasks increases. In our model, Workers observe both tasks with certainty, while Managers observe each task independently with some probability p, known $ex - ante$ by all agents. We assume each Worker receives a fixed payment that is sufficient to cover their best outside option, and focuses on minimizing their own cost, $|\theta_i – t_i^f|$.

The timing of decisions in this game is as follows:

1. Given p, the Manager chooses whether to delegate the rights to reallocate tasks.
2. The Manager chooses (θ_1, θ_2) and the Workers receive randomly drawn tasks, (t_1^0, t_2^0).
3. The Manager observes each task with an independent probability p, while Workers observe both tasks.
4. The Manager (if in a centralized organization) or the Workers (if decentralized) determine

[5] We obtain qualitatively similar results assuming symmetric unimodal distribution functions defined on the same interval. However, this simple setup facilitates both experimental participant comprehension and our empirical analysis.

the final task assignment, $(t_1^f, t_2^f) \in \{(t_1^0, t_2^0), (t_2^0, t_1^0)\}$.

5. Costs for the Manager and Workers are realized.

A centralized organization allows the Manager to reallocate tasks directly after observing one, both, or neither task. In particular, a Manager unable to observe either task leads to potentially costly mistakes in task allocation, either by switching tasks when they should remain, or missing the opportunity to profitably switch tasks. In proposition A.1 in the appendix, we show the task allocation rule of the Manager based on the number of observed tasks. We can then use backward induction to analyze how Managers optimally select their teams in a centralized organization. Recall that Managers choose their team before learning if they will observe neither, one or both original tasks, but knowing they will face those cases with probability $(1-p)^2$, $2p(1-p)$, and p^2 respectively. This allows the Manager to map the probability to exchange tasks for any pair of (t_1^0, t_2^0) for a given (θ_1, θ_2). Then, the Manager has to select the specializations of both Workers that allows them to minimize their $ex-post$ errors in task reallocation. Solving this problem captures our hypothesis *H1A*.

In a decentralized organization, Workers make the task allocation decision by voting to switch tasks or not. When a Worker is assigned their initial task, they also see the task of the other Worker in their group. If their task is farther from their position than the other Worker's task, they will vote to switch. Only if both Workers vote to switch will the tasks be exchanged.[6] Critically, this implies that the Manager and Workers have imperfectly aligned incentives. Figure 1 shows a case where the Manager would like to exchange the tasks but one of the Workers will not. The reallocation of tasks in this case would maximize the joint profits for the entire group, yet because Workers do not internalize the impact of their decisions on their co-Worker's cost, reallocation may not occur.

FIGURE 1: MAIN INCENTIVE PROBLEM IN A DECENTRALIZED ORGANIZATION

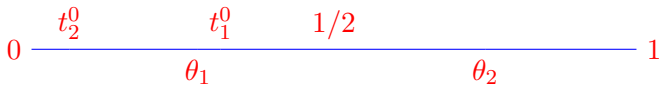


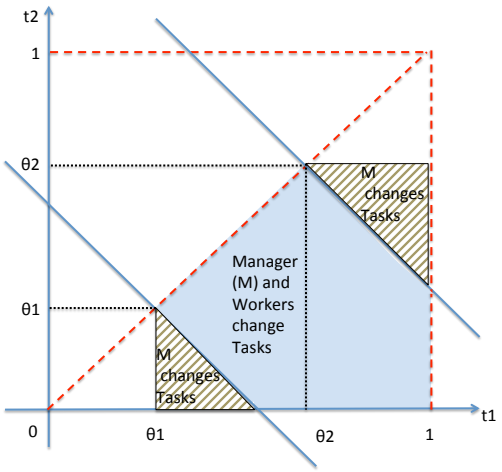
Figure 2 represents all cases where the Manager and Workers want to reallocate tasks on the plane (t_1^0, t_2^0) for a particular (θ_1, θ_2). The shaded area highlights the cases in which both Workers agree to reallocate tasks. The two striped triangular areas show cases in which the Manager would like to exchange tasks when they have perfect information ($p = 1$), yet one of the Workers does not.[7] Here, we see that if the Manager selects more homogeneous teams, cases such as that shown in Figure 1 will become more frequent (the triangular areas grow larger). On the other hand, selecting overly heterogeneous teams will lead to more switching (in line with the Manager's preferences), but at a higher total cost, as Workers will be farther, in expectation, from their tasks. Managers must therefore select their teams to minimize the total expected cost, given the Workers decision to reallocate tasks or not. Since the Manager affects

[6] We fully characterize the conditions under which each worker will vote to switch tasks in Appendix A.

[7] Worker θ_1 prevents reallocation in the bottom left, while Worker θ_2 prevents reallocation in the top right. In this graphical example we assume symmetric positions around $E[t^0]$, but this is not a necessary condition.

the final decisions of the Workers only through the positions selected, the optimal positions are independent of the level of information p, capturing *H2A*.

FIGURE 2: REALLOCATION REGIONS IN A DECENTRALIZED ORGANIZATION



Given the optimal team selection in centralized and decentralized organizations, we can integrate them into the Manager's organizational structure decision to compare the expected costs generated by both decisions based on the level of information, p. In Appendix A.4, we show that a Manager prefers to have the right to reallocate tasks when the level of information is "good enough." On the other hand, when the Manager's information is poor, they prefer to delegate task reallocation rights to the Workers, as predicted in *H3A*. We also show that Managers in this simple model have a unique optimal solution for each level of information. The latter is important because we use these point predictions to analyze the moderating role of deliberative thinking and risk preferences.

4.2 Experimental design

We implemented a hybrid between/within design in which participants were randomly assigned a role of Manager (M), Worker 1 (θ_1), or Worker 2 (θ_2) in three-person groups. In the sessions, roles were denoted Participant A, Participant B1, and Participant B2 and the experiment was presented as one of economic decision-making to avoid framing effects. Our subjects were typical undergraduate student populations currently enrolled at the university. For expositional ease, we continue to use "Manager" and "Worker" to indicate participants in each role, capitalized throughout to clarify that we refer to the role, rather than individuals who hold such positions outside the lab.

In the experiment we used a uniform distribution of the tasks over the support $[0, 100]$. We examined four different treatments, each capturing a different level of information. Specifically, the probability p took one of the following fixed values in each treatment: $[0.2, 0.5, 0.8, 0.9]$. The body of experimental work on the control premium (among other topics) demonstrates that people are much more likely to suboptimally retain control than to suboptimally cede control. Thus, we focus more on values of p below $p^* = 0.82$, which is the information threshold

computed from our benchmark model in Appendix A. Our design allows us to examine the behavior of participants as they approach the information threshold in three environments that call for decentralization, and one in which centralization is optimal.

Each session was broken into three blocks. Blocks 1 and 2 lasted ten rounds each with either Centralized or Decentralized organizational structure, fixed during the block (counterbalanced for each value of p). It was announced that groups would be fixed for each block with random rematching between blocks. This gives the Manager experience with team selection in both a centralized and decentralized environment, after which they enter a third block in which they decide both team selection and the organizational structure as well, which we describe below. Thus, each participant entered the third block having played ten rounds of each organizational structure, beginning with either Centralized or Decentralized. This provides a stronger test of the model by giving participants feedback in both settings before they must choose the organizational structure themselves.

In repeated play, one concern in evaluating the model's predictions rises from the potential for reputation-seeking and reciprocity. Indeed, repeated play has been found in some studies to encourage reputation-seeking, though not always in predicted ways (see, for example, Tingley and Walter (2011)). However, repetition allows for feedback and learning about the environment, to better ensure a proper understanding of the game rules. Rather than adopting a one-shot design, we used repeated play with reshuffled groups before each new stage. This helps to minimize reputational concerns and guarantees that at least in the first round of each stage no reputation effect is at play. We address this in the results section, and explore more channels for possible reputational or reciprocal effects in Appendix B.6. In summary, we find no clear evidence of either motive.

At the beginning of each round, participants were reminded the value of p for the session and the role they were assigned. Then, Managers chose Workers θ_1 and θ_2 by assigning each a "placement" between 0 and 100. Once both Workers had been placed, the positions of the tasks assigned to each Worker were revealed. Workers saw both task positions with certainty, and knew which task had been matched to them. Managers saw each task position independently with the probability p for that session.

Once each task was revealed or not to all group members, participants completed a "switch" task. This task determined whether the Workers would switch their originally assigned tasks or not. Participants knew that Workers and tasks could not be repositioned; they could only switch which task was assigned to which Worker. In the Centralized environment, the Manager made the switch decision unilaterally, whether they saw one, both, or neither task position.[8] In the Decentralized environment, Workers voted over whether to switch. Only through unanimous vote to switch could Workers exchange tasks. If only one Worker voted to switch, the tasks remained as initially assigned. After the switch task, payoffs were realized for the round.

[8] Analogously, imagine a situation in which a manager has a task that must be divided into sub-tasks. The manager may know the task but is not clear on how to decompose it. One, multiple, or no sub-tasks may be identifiable ex-ante. Thus, each sub-task may have its own degree of uncertainty, and so full decomposability may not be feasible.

Payoffs in experimental currency (ECU) are given by $ECU_{\theta_i} = 50 - |t_i - \theta_i|$ for Worker i and $ECU_M = 50 - 0.5\sum_i |t_i - \theta_i|$ for the Manager, where task t_i is matched with Worker θ_i at the end of the round. Note that Workers simply aim to minimize their distance from their task, while Managers minimize the joint distance. These formulas were explained to participants with several examples and reiterated with intuitive explanations, and participants were given a calculation screen during the instructions with which to familiarize themselves with the payoffs (see Appendix C for experimental materials). It was possible, though improbable, for participants to earn negative payoffs in a round. To minimize this risk, participants knew they would receive their total earnings collected over all rounds of the session.

Once participants completed both the placement and switch tasks, results were displayed providing them with information about their decisions in that round and their payoffs. In the Centralized rounds, Workers were informed of their final assigned task, task positions, whether the Manager switched tasks, and the payoffs of all group members. Each Manager was reminded of any task position revealed, but Workers did not see which task positions had been revealed to the Manager. In the Decentralized rounds, the Manager was notified whether or not the Workers chose to switch tasks; otherwise, the information revealed was the same.

At the conclusion of the second block, participants were read instructions for block 3, the Selector stage. Block 3 consisted of 16 rounds that were identical to blocks 1 and 2 with one addition. Prior to making the placement decision, the Manager made a new decision to begin each round of block 3 that determined whether that round would be played in a Centralized or Decentralized environment. Specifically, the Manager selected whether she or the Workers would complete the switch task for the round. Once the Manager made this choice, they completed the placement decision and the round then mimicked either a round from block 1 or a round from block 2.

Following the Selector stage, participants completed a demographic survey, an incentivized risk elicitation measure (Eckel and Grossman, 2008), and the Cognitive Reflection Test, or CRT (Frederick, 2005).[9] The CRT is designed to measure deliberative thinking and resistance to impulsive choices and is one of the most utilized recent measures of deliberative thinking in experiments (Frederick, 2005).[10] Scores on this test correlate strongly with other cognitive measures (Benjamin, Brown and Shapiro, 2013; Dohmen et al., 2010; Frederick, 2005) and behavioral heuristics (Oechssler, Roider and Schmitz, 2009), yet it better predicts behaviors in a wide range of choice tasks (Toplak, West and Stanovich, 2011).[11]

4.3 Experimental procedure

Initial sessions of the 20%, 50%, and 80% treatments were run at Pompeu Fabra University in Barcelona, each with counterbalanced order of the first two stages, for a total of six sessions.

[9] See Appendix C.5 for the full risk elicitation measure and Appendix C.6 for the CRT questions.

[10] For more information about the use of the CRT test see a recent meta analysis by Brañas-Garza, Kujal and Lenkei (2019).

[11] The CRT is commonly unincentivized, as in our study. Brañas-Garza, Kujal and Lenkei (2019) examine over one hundred studies involving the CRT and find no effect of incentivization on performance.

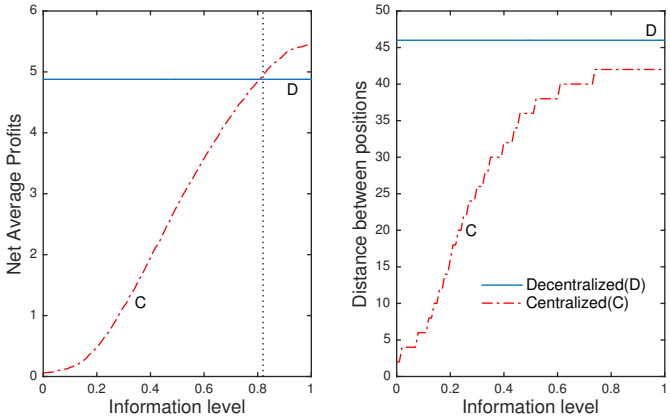
A second round of six identical sessions were run in the xs/fs laboratory at Florida State University. For logistical reasons, all four sessions of the 90% treatment were conducted at Florida State University, retaining the counterbalanced ordering. Participants at Florida State were recruited using ORSEE (Greiner, 2015) and all sessions were run using the zTree software (Fischbacher, 2007). Sessions consisted of 21 or 24 participants, and each participant received a \$10 (€5) show-up fee in addition to money accumulated from the game. Sessions lasted just under two hours and average earnings were approximately \$24 and €16 (\$22) in the two locations, respectively. In Appendix C, we detail the randomized recruitment procedures and report power calculations confirming that our sample size gives us enough power to identify the results we report below.

Instructions were read aloud in each session, indicating the value of p for the session (translated to Spanish for sessions in Barcelona by a native speaker also fluent in English). After reading the instructions for block 1, participants were randomly assigned a role of Manager, Worker 1, or Worker 2 (referred to as role A, B1, and B2, respectively) in three-person groups. Participants were only read instructions for each block as it was reached, though they knew there would be three blocks from the beginning. They also knew that they would play in the same role and face the same value of p for all blocks. During the instructions at the beginning of the session, all participants were given the chance to familiarize themselves with the placement and switch decision using the exact same screen they would see during the experiment.

4.4 Benchmark predictions

Figure 3 represents a Monte Carlo simulation of the benchmark model's predictions given the experimental parameters chosen.[12] In the left-hand panel, we plot the net average payoffs minus the expected payoffs obtained with a perfectly homogeneous "50-50" team (25 ECU per round).

FIGURE 3: ORGANIZATIONAL STRUCTURE AND TEAM SELECTION PREDICTIONS



Notes. Differences between expected profits as information quality increases by organizational structure (left). Differences between selected positions as information quality increases by organizational structure (right).

[12] We use a Monte-Carlo simulation with 100 Managers playing 500 rounds for values of $p \in [0, 1]$, focusing on symmetric positions of (W_1, W_2) around the ex-ante expected task.

Notice in the left-hand panel that the value of p^* predicted by the model for this experiment is approximately 0.82. At this value, the participant in the role of Manager is indifferent between the two types of organization. For values above 0.82, the Manager prefers a centralized organization; and for values below, the Manager prefers to delegate.

In the right-hand panel of Figure 3, we plot the optimal distance between positions for the different levels of p. The model predicts the following regarding team selection: In a centralized organization, the Manager should select the positions around $(42, 58)$ in the 20% treatment, positions $(35, 65)$ in the 50% treatment, positions $(31, 69)$ in the 80% treatment and positions $(30, 70)$ in the 90% treatment. In a decentralized organization, the Manager should select the position of $(27, 73)$ in all the treatments independently of the level of information.

In the Selector stage, the model predicts that the Manager should delegate if the level of information is 20, 50 or 80%, but should retain control of task allocation in the 90% treatment. Additionally, the model predicts more heterogeneity in Worker positions in decentralized organizations than in centralized organizations for all information levels, including the 90% treatment. In the next section, we use these optimal predicted positions and optimal organizational structure to analyze decisions under different levels of uncertainty, focusing on how a Manager's behavorial traits may explain deviations from these benchmark targets.

5 Experiment Results

We take a comparative-static approach to testing our model, in which we aim to compare our data to the model's predictions based on our chosen parameters (Schotter, 2015). As classified in Schotter (2015), a "strong" comparative-static approach explicitly tests whether our results match the model's point predictions. Due to the extreme point predictions made by the model, however, we expect a "weak" test to be more accurate, comparing our results more qualitatively to directional predictions of the model. Here is where we expect to see the impact of our behavioral characteristics - deliberative thinking and risk tolerance - as they will let us examine what factors enable participants in the Manager role to come closer to the model's predictions.

We conducted a total of sixteen sessions, with four counter-balanced sessions per treatment (two sessions following the C-D-Selector path and two the D-C-Selector path). We did not conduct pilot sessions or any sessions for treatments not reported in the previous section. We did not exclude data from any participant, nor did we collect any demographic variables not reported here. Therefore, the data we use in this section come from our entire sample. The dataset and fully commented analysis code are available upon request.

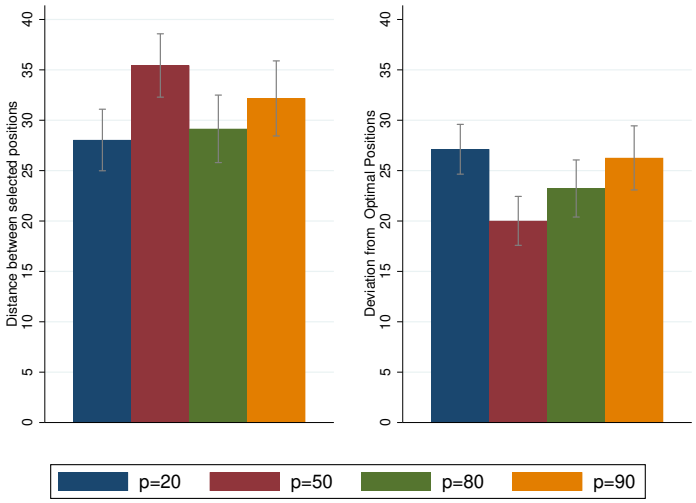
Table C.1 in the Appendix C provides summary statistics showing no significant differences in demographics between location among Managers. Similarly, Table C.2 shows no demographic differences among Managers by treatment. Combined, these suggest that participants were successfully randomized into treatments. Nonetheless, our analyses include regressions both with and without demographic controls to show the robustness of our reported results.

We proceed by analyzing our hypotheses in order, focusing on data from the second half of each stage to avoid confusing learning effects in the first half. We then turn to explore mechanisms behind our observed patterns of behavior.

5.1 Centralized Team Selection

Hypothesis *H1A* suggests that the team heterogeneity should decrease as the level of information declines in a centralized organization. The left-hand panel of Figure 4 plots the average distance between selected positions by treatment in the centralized stage. In this figure, we observe significantly less heterogeneity in the 20% with respect to the 50% and 90%, but not from the 80% treatment. However, in the centralized rounds of the Selector stage (see Figure B.2 in Appendix B.1), teams in the 20% are more homogeneous, but there are no significant differences among the 50%, 80% and 90% treatments, offering some support for *H1A*, but only in the lowest information environment.

FIGURE 4: TEAM SELECTION IN CENTRALIZED ORGANIZATIONS



Notes. Distance between selected positions (left) and deviation from optimal positions (right). Confidence intervals at 95% level.

If we compare the average results in the left-hand panel of Figure 4 with our point predictions, we see that the average team is more specialized in the 20% and 50% treatments and less specialized in the 80% and 90% treatments. The right-hand panel shows the amount of deviation from the optimal positions predicted by the model. Managers make worse decisions than predicted in both low and high levels of uncertainty, which is not surprising since those environments called for the least and most specialized teams, respectively.[13]

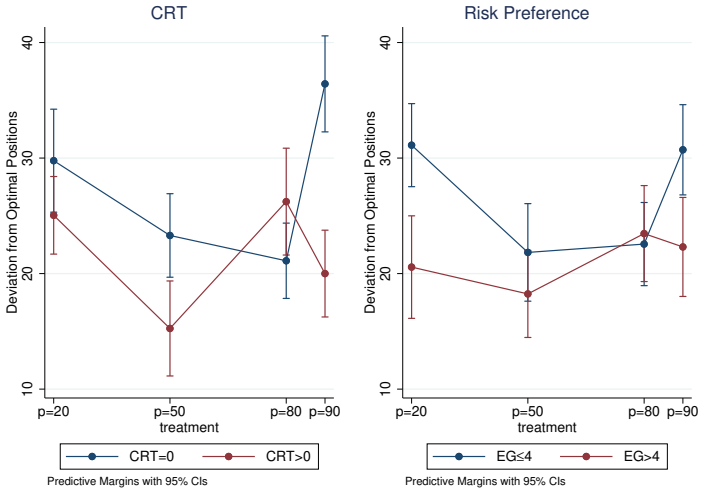
Table B.1 in Appendix B.2 shows regression results to complement these figures, using the deviation from predicted positions as a dependent variable. The first column shows that Man-

[13]The right-hand panel in Figure B.2 in Appendix B.1 shows that there are no signifcant differences among treatments in the centralized rounds of the Selector stage, except the 20% treatment. The worse performance of Managers in the 20% treatment is not surprising since Managers should decentralize, implying greater distance between optimal team positions among organizational structures.

agers make significantly worse decisions in the 20% treatment, and when we include additional controls, we find a similar result in the 90% treatment. These results confirm the difficulties our Managers have when dealing with too little or too much information. To understand these difficulties more deeply we turn to analyze our moderating hypotheses *H1B* and *H1C*.

H1B suggests that deliberative thinking moderates the relationship between the treatments and team selection.[14] Specifically, *H1B* hypothesizes that an impulsive Manager will be more likely to deviate from the predicted positions than a more reflective Manager for any level of information. The left-hand panel of Figure 5 supports this prediction, illustrating the predicted deviation from the optimal team. These capture the marginal effects of regressions reported in Table B.1, which include multiple controls and interactions. A more reflective Manager chooses Worker positions closer to those predicted by the model in the 20, 50 and 90% treatments, and these effects are statistically significant in the last two.

FIGURE 5: TEAM SELECTION AND MODERATING EFFECTS IN CENTRALIZED ORGANIZATIONS



Notes. Predicted deviation from optimal positions by treatment, interacted with cognitive reflection (left) and risk tolerance (right), derived from regression results reported in appendix Table B.1. Confidence intervals at 95% level.

H1C similarly suggests a moderating role of risk preferences in the team selection decision.[15] Risk aversion should cause a Manager to deviate further from the optimal expected positions for any level of information in a centralized organization. The right-hand panel of Figure 5 shows

[14] We compare the organizational structure and team selection choices by less ($CRT = 0$) and more reflective ($CRT > 0$) Managers. We follow Brañas-Garza, García-Muñoz and González (2012) and Corgnet et al. (2014) in pooling the cognitive reflection test (CRT) scores above zero, as a correct answer on any of the three questions indicates some ability to override one's initial impulse. In our data, 60 Managers answered zero questions correctly, 30 answered one question, 21 answered two, and 7 answered all three questions correctly. Thus, our Manager participants are split nearly in half by this categorization. We also report regression results in appendix Table B.5 using continuous versions of our CRT variable. Our results are robust to this alternative specification.

[15] We classify Managers as more risk averse ($EG \leq 4$) or risk tolerant ($EG > 4$). This again splits our Managers nearly in half with treatments well-balanced. Dividing the risk measure into $EG \leq 3$ vs $EG > 3$ also divides the data relatively equally, but leaves larger between-treatment asymmetries. We therefore decided before conducting data analyses to use the break along an EG choice of 4. The results do not differ significantly under the alternate specification. We also report regression results in appendix Table B.6 using continuous versions of our EG variable. Our results are robust to this alternative specification. Like many prior studies, we find positive but relatively modest correlation between CRT and risk tolerance ($\rho = 0.23$, $p < 0.001$ using a two-tailed t-test).

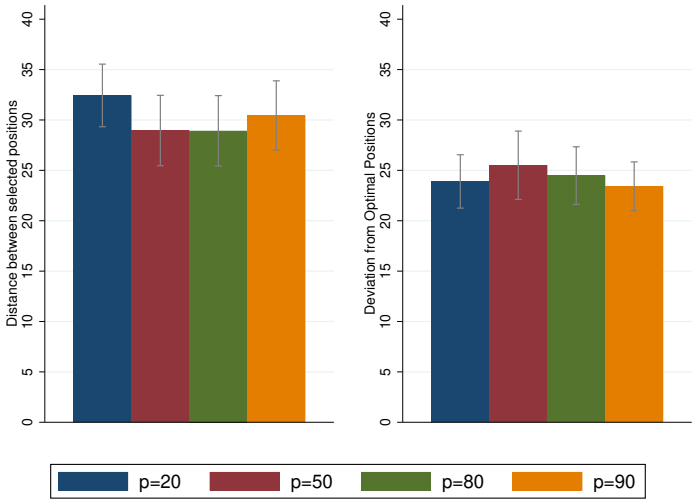
that risk tolerant Managers choose Worker positions closer to those predicted by the model in the 20, 50 and 90% treatments, with statistically significant differences in the 20 and 90% treatments.

Figure 5 provides the first evidence of complementarity between risk tolerance and cognitive reflection. Namely, risk tolerance is more impactful in the high risk environments while cognitive reflection has a stronger effect in low risk environments in the centralized organization. These outcomes have a real impact on Manager payoffs. Figure B.9 in Appendix B.4 shows that reflective and risk tolerant agents are closer to the maximum possible payoffs in the 20 and 90% treatments.

5.2 Decentralized Team Selection

H2A suggests that Worker heterogeneity should be independent of the Manager's level of information when they delegate because Workers have perfect information in each treatment. The left-hand panel of Figure 6 shows a stable distance between selected positions by treatment with no statistically significant differences, in line with our prescriptive prediction. The right-hand panel also shows insignificant differences between the selected positions and optimal positions predicted by the model. The positive values reflect more homogeneous teams than predicted.[16]

Figure 6: Team Selection in Decentralized Organizations



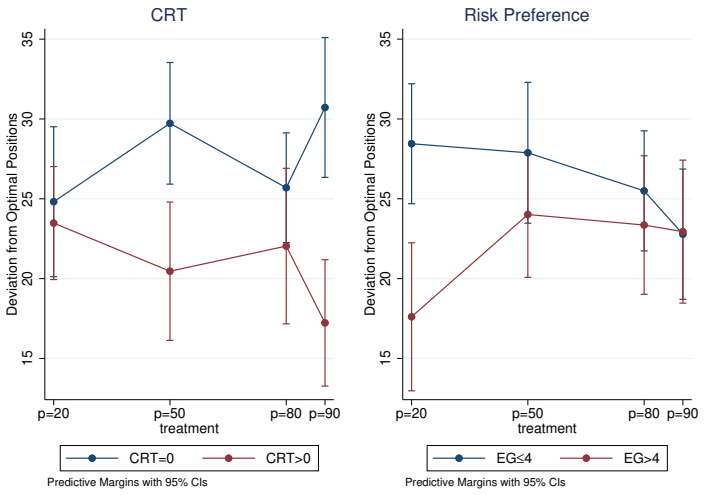
Notes. Distance between positions (left) and deviation from optimal positions (right). Confidence intervals at 95% level.

In Appendix Table B.2, we confirm using regression analysis that there are no significant differences among treatments, regardless of included demographic controls. When we add interaction effects to analyze the moderating role of risk tolerance and cognitive reflection, we see that these characteristics are the reason for confirming *H2A*. Figure 7 reports marginal effects from these regressions. More deliberative Managers choose more heterogeneous teams

[16]In the decentralized rounds of the Selector stage we observe significantly more heterogenous teams in the 20% treatment, with greater deviation from optimal positions in the 90% treatment. The latter possibly driven by the fact that the optimal organizational structure in this treatment is a centralized organization.

in all treatments, with large and significant differences in the moderate and lowest uncertainty settings. Clearly, deliberative thinking is an important factor in a decentralized organization facing low uncertainty environments, as seen in the left-hand panel, offering limited support for *H2B* when all Managers must delegate.

FIGURE 7: TEAM SELECTION AND MODERATING EFFECTS IN DECENTRALIZED ORGANIZATIONS



Notes. Predicted deviation from optimal positions by treatment, interacted with cognitive reflection (left) and risk tolerance (right), derived from regression results reported in appendix Table B.2. Confidence intervals at 95% level.

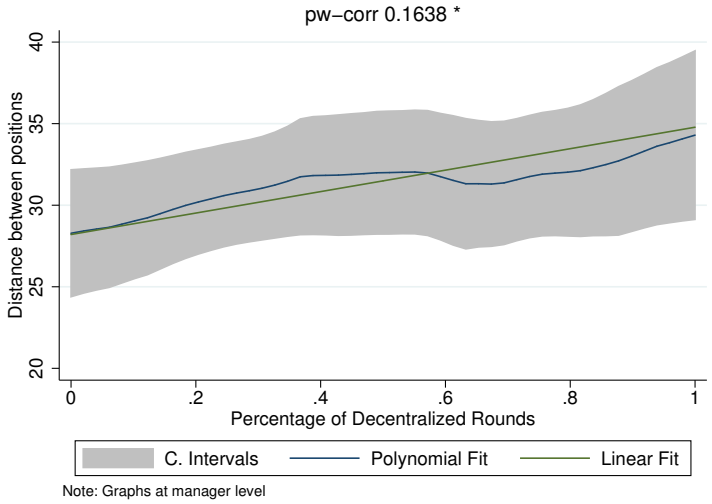
H2C similarly predicts that risk aversion moderates the relationship between the treatments and team selection. We observe significant effects in the high uncertainty environment, as shown in the right-hand panel of Figure 7. Unlike in the Centralized stage, where risk tolerant and more reflective Managers performed better in the 50% treatment, in a decentralized organization, risk tolerant agents do much better in the 20% treatment (high uncertainty environments) while more reflective agents outperform in the 90% treatment (low uncertainty environments). Thus, in a decentralized organization we again find evidence of complementarities between these two behavioral characteristics. Figure B.10 in Appendix B.4 shows that reflective agents are closer to the maximum possible payoffs in all treatments, while and risk tolerant agents are closer to the maximum possible payoffs in all but the 90% treatment.

5.3 Selector Stage Results

So far, we have analyzed the effect of uncertainty on team specialization under fixed organizational structures. In this section, we examine how these decisions change when Managers must select their organizational structure as well. Recall that the allocation of decision rights and team selection are endogenously related, theoretically, in helping Managers navigate uncertainty. Figure 8 plots the average distance between positions selected by each Manager and the percentage of rounds in which they delegated the task allocation decision in the Selector stage. We obtain a positive and significant correlation among these variables as predicted, though its

magnitude is modest. In the following analyses, we explore the degree to which our behavioral characteristics moderate the strength of this relationship.

FIGURE 8: DELEGATION AND TEAM SELECTION IN THE SELECTOR STAGE



Notes. Percent of rounds delegated and average distance between selected positions by Manager in the Selector Stage

5.3.1 Team Selection

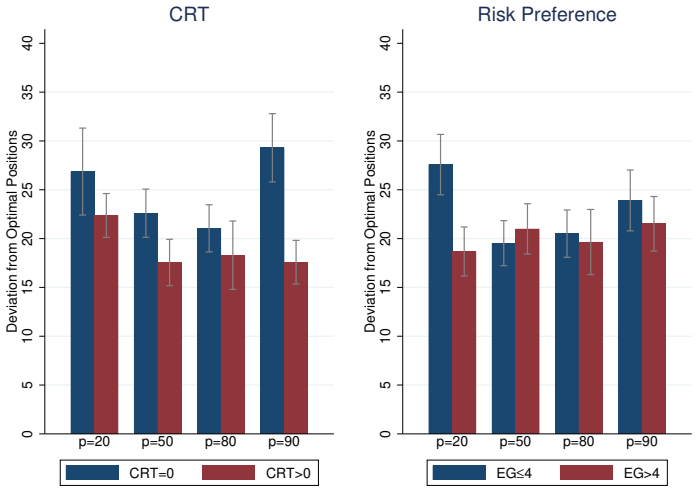
There are no statistical differences in the distance between selected positions among treatments. However, we observe larger and significant differences when we measure how far selected positions are from the model's predictions. This suggests that Managers have greater difficulties navigating environments with extremely low and high levels of uncertainty as shown in Figure 4 in Appendix B.1.[17] Table B.3 in Appendix B.2 confirms these differences using regression analysis. Note that the deviation in the 80% treatment is smaller than what we observe in a centralized organization (Table B.1) in most cases.

The interesting results in this case are driven largely by our moderating characteristics. Figure 9 shows the average deviation from predicted positions by cognitive reflection and risk tolerance across treatments. The left-hand panel shows that more reflective Managers do significantly better in their team selection decisions in all treatments. Note in particular the large deviation by the less reflective Managers in the environment with higher uncertainty, where their teams are almost twice as far away from the model prediction compared to the more reflective participants. The right-hand panel shows that risk tolerant Managers make better team selection decisions in the extreme levels of information, both low and high. The impact of risk tolerance grows as information quality worsens, consistent with the notion that risk tolerant individuals react better in more uncertain environments.

We examine these results over time in the Selector stage in Appendix B.3. Cognitive reflection is critically important for team selection, both in proximity to the model's predictions and in

[17] Managers are selecting more asymmetric teams in the 20 and 90% treatments. Thus, even if the distance between positions is equal, the deviation from optimal positions is not.

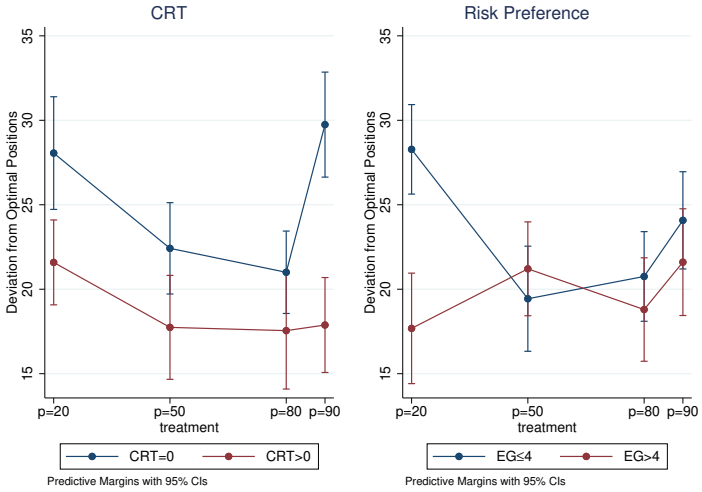
FIGURE 9: TEAM SELECTION IN THE SELECTOR STAGE



Notes. Deviation from optimal positions in each treatment, by cognitive reflection (left) and risk tolerance (right). Confidence intervals at 95% level.

stability over rounds. In each treatment, we see that more reflective Managers are statistically closer to the benchmark predictions and more stable in their strategies, particularly in the 20% treatment. We also confirm that risk tolerance only improves team selection in the 20% treatment. Thus, the evidence suggest that cognitive reflection is even more relevant for team selection than risk aversion, which we confirm in Figure 10, plotting predicted deviation from the optimal predictions from regression models 4 and 7 in Table B.3.

FIGURE 10: TEAM SELECTION AND MODERATING EFFECTS IN THE SELECTOR STAGE

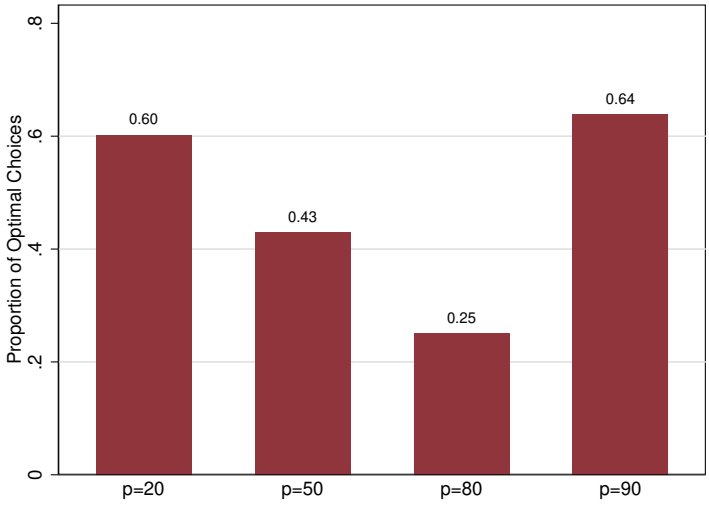


Notes. Predicted deviation from optimal positions by treatment, interacted with cognitive reflection (left) and risk tolerance (right), derived from regression results reported in appendix Table B.3. Confidence intervals at 95% level.

5.3.2 Allocation of Decision Rights

The results change markedly when we turn to the delegation decision. *H3A* predicts that Managers will delegate more as uncertainty grows. Our benchmark model is more extreme, predicting that Managers will delegate in favor of a decentralized structure for all information conditions except the 90% treatment. Figure 11 plots the percentage of rounds in which Managers choose the optimal organizational structure in the Selector stage by treatment. Managers make the largest proportion of optimal decisions in the most extreme information environments, significantly more than in the 50% and 80% treatments (Pearson's chi-squared = 129, $p = 0.000$). While Managers do not delegate in all rounds below the threshold, they do so significantly more often when facing poorer information, in line with *H3A*.

FIGURE 11: OPTIMAL ORGANIZATIONAL STRUCTURE BY TREATMENT



Notes. Percentage of optimal organizational structure decisions in the Selector stage.

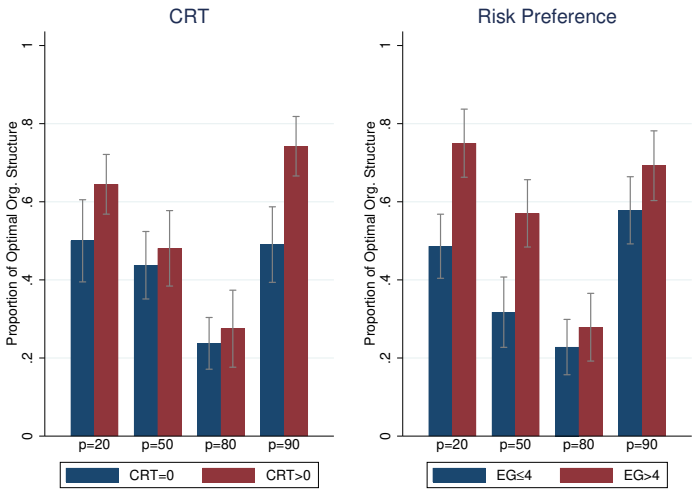
Interestingly, Managers are quicker to adopt the optimal structure when centralization is preferred, retaining decision rights 64% of the time in the 90% treatment, where they are only 8 percentage points above the threshold. On the other hand, Managers are more reluctant to increase their use of delegation as their information level declines. They reach similar levels of optimal structure choices only in the 20% treatment (selecting decentralized groups 60% of the time), where their information quality is 62 percentage points below the threshold. This is again suggestive of the strength of the desire to maintain control of decisions (Bartling et al., 2014; Fehr, Herz and Wilkening, 2013; Owens, Grossman and Fackler, 2014).

To further explore the organizational structure decisions in our experiment, we use logistic regressions with demographic controls, and report various specifications in Table B.4 in Appendix B.2. The results are robust to many alternative specifications. Consistent with Figure 11, all treatment coefficients are positive and significant. Moreover, the coefficients for 20% and 90% treatments are roughly double that of the 50% treatment in all specifications (a statistically significant difference). We confirm the convex pattern from Figure 11, that moving away from the threshold causes Managers to more frequently select the optimal organizational

structure.

The left-hand panel of Figure 12 addresses *H3B*. We see that more reflective participants select the optimal organizational structure more often in every treatment with significant differences in the 20 and 90% treatments, with the largest effect seen under the lowest level of uncertainty. On the other hand, the right-hand panel of offers stronger support for *H3C*. Risk tolerant Managers select the optimal organizational structure significantly more in every treatment except the 80%, with the largest effects seen under the highest level of uncertainty. Risk tolerance has a growing impact as information quality worsens, conceptually similar to the result observed in Figure 8 above.

FIGURE 12: OPTIMAL ORGANIZATIONAL STRUCTURE BY REFLECTION AND RISK TOLERANCE

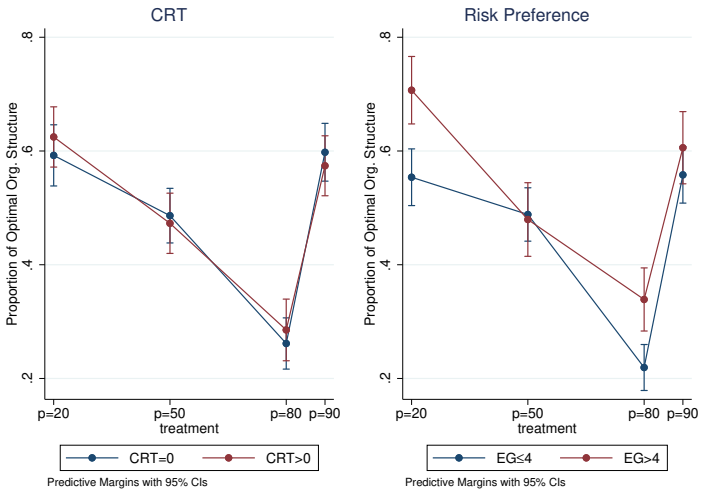


Notes. Percentage of optimal organizational structure in each treatment, by cognitive reflection (left) and risk tolerance (right). Confidence intervals at 95% level.

Again, we report round-by-round trends for the Selector stage in Appendix B.3, which confirms our results that risk tolerant Managers choose the optimal organizational structure more often, with the strongest improvements coming under greater uncertainty. While more reflective participants show consistently higher proportions of optimal decisions, we do not observe a large difference outside of the environment with the lowest level of uncertainty.

Figure 13 plots the predicted probability to delegate based on regressions in columns 4 and 7 from Table B.4, which include our demographic controls. While we continue to find a clear impact of risk aversion in all treatments except the 50%, cognitive reflection now plays a reduced role. Cognitive reflection and risk tolerance have complementary roles in these organizational decisions. Risk tolerance helps to deal with the allocation of decision rights while cognitive reflection is more effective in dealing with the team specialization decision. Figure B.8 in Appendix B.4 shows that reflective and risk tolerant agents are closer to the maximum possible payoffs in almost all treatments in the Selector stage.

FIGURE 13: ORGANIZATIONAL STRUCTURE AND MODERATING EFFECTS IN THE SELECTOR STAGE



Notes. Predicted percentage of optimal organizational structure by treatment, interacted with cognitive reflection (left) and risk tolerance (right), derived from regression results reported in appendix Table B.4. Confidence intervals at 95% level.

5.4 Moderator Mechanisms

We have shown that both risk tolerance and reflection help Managers in our experiment make better decisions for both organizational structure and team heterogeneity, though in more nuanced ways than the behavioral hyphotesis suggested. In this section, we shed some light on two identifiable mechanisms behind these effects. We observe that cognitive reflection and risk tolerance each have two distinct effects. They a) lead to better decisions in the first round of each stage and b) enable Managers to avoid over-reacting to observed results in a given round. In discussing these mechanisms, we will again see evidence of the complementary role of each moderator.

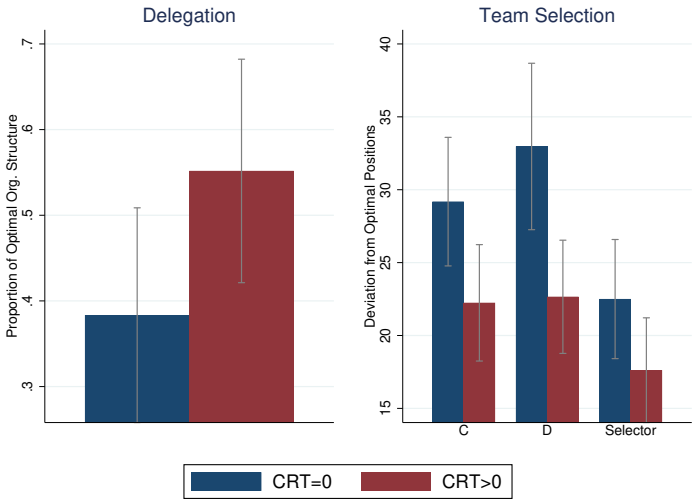
5.4.1 Initial Decisions

One possible concern that emerges from the dynamic nature of the experiment is the potential for reciprocity and reputational concerns to impact outcomes. In Appendix B.6, we investigate this possibility in depth and find no evidence of these repeated-play motives in the data. Nonetheless, it is informative to examine decisions made in the first round of each stage, without group histories. This gives us a cleaner test of the role of moderators without repeated-play confounds.

Figure 14 plots the average of the percentage of both Manager decisions in the first round of each stage, split by CRT scores. Cognitive reflection significantly increases the probability to select the optimal organizational structure and significantly reduces the deviation from optimal team composition in each initial round. This is in line with our hypotheses and our previous results. There is also a significant reduction in the deviation from optimal team compositions when we compare the Selector stage with preceeding stages, independent of the cognitive re-

flection level, suggesting that reflective participants outperform when they have the possibility to make both decisions together.

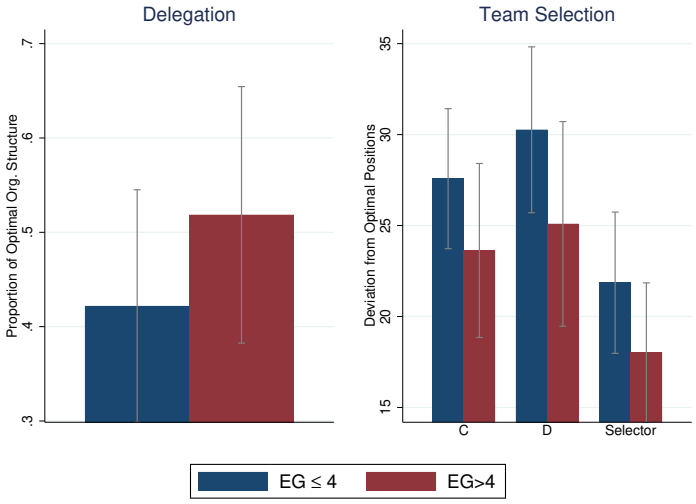
FIGURE 14: FIRST ROUND DECISIONS BY COGNITIVE REFLECTION



Notes. Percentage of optimal organizational structure decisions (left) and deviation from optimal team composition (right) by Managers in the first round of each stage, by CRT score.

Figure 15 replicates the previous analysis by splitting Managers according to their level of risk tolerance. The patterns we observe are qualitatively similar but not significant. However, comparing data pooled from all stages shows a significant reduction in the deviation from optimal team positions for the risk tolerant Managers in comparison with their risk averse counterparts.

FIGURE 15: FIRST ROUND DECISIONS BY RISK AVERSION



Notes. Percentage of optimal organizational structure decisions (left) and deviation from optimal team composition (right) by Managers in the first round of each stage, by risk preference.

5.4.2 Reactions to Feedback

If Managers experience a bad outcome in a round, they may view a reduction in team heterogeneity as a defensive measure to protect against this in future rounds. However, as Figure 2 shows, reducing team heterogeneity increases the regions in which Managers may experience bad outcomes. Similarly, Managers may react by maintaining control of decision rights if prior bad outcomes came under delegation, which is a costly reaction in all treatments aside from 90%. Managers who can resist such intuitive responses may perform better. To disentangle the effects of these two possible responses, we analyze reactions in the first two blocks where Managers only control the team heterogeneity and their reactions in the Selector stage where they control both team heterogeneity and decision rights.

We define our measure of a bad outcome as a payoff below what would be expected had the Manager chosen a perfectly homogeneous team, which minimizes the variance and expected value of their payoffs to 25 ECU. Therefore, our measure takes the value of 1 for payoffs below 25 and 0 otherwise (which we refer to below as "good outcomes").[18]

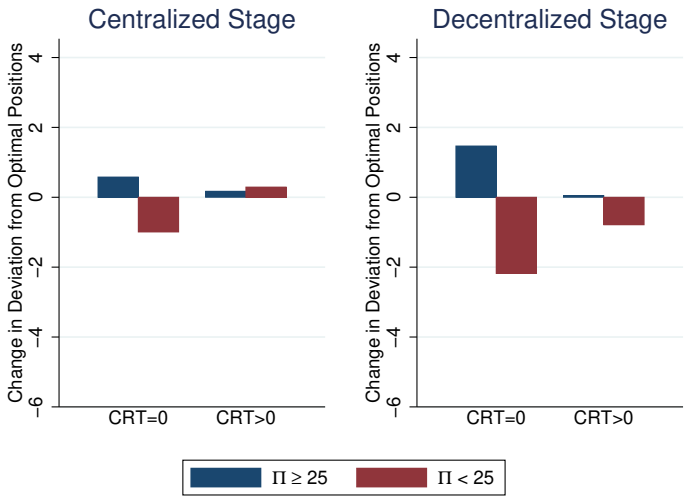
To begin, we analyze a Manager's reaction to prior outcomes in their team selection decision. Specifically, we compare the change in deviations from optimal positions in the first two blocks, reported in Figures 16 and 17. It is evident that high-CRT Managers are less reactive to the payoffs obtained in the previous period. Interestingly, this behavior is present for both good and bad outcomes and for both centralized and decentralized organizational structures. Moreover, the differences are particularly high in the decentralized rounds, possibly because Managers may blame Workers for any bad results observed if they think Workers made decisions against their preferences.

This is not the case for risk tolerance. Figure 17 suggests that risk tolerant Managers are more reactive in centralized organizations but less so in decentralized ones, especially after observing a bad result. We also observe stronger reactions in the decentralized organization for all agents.

When analyzing the reactions of Managers in the Selector stage, we observe more muted reactions for both reflective and risk tolerant participants as shown in Figure 18. Cognitive reflection has the strongest effect. Taken together, these findings suggest that reflective Managers think more carefully about their decisions in the first rounds and are less prone to reacting impulsively. Risk tolerance is more important in decentralized organizations and when the Manager has the option to select the organizational structure as well.

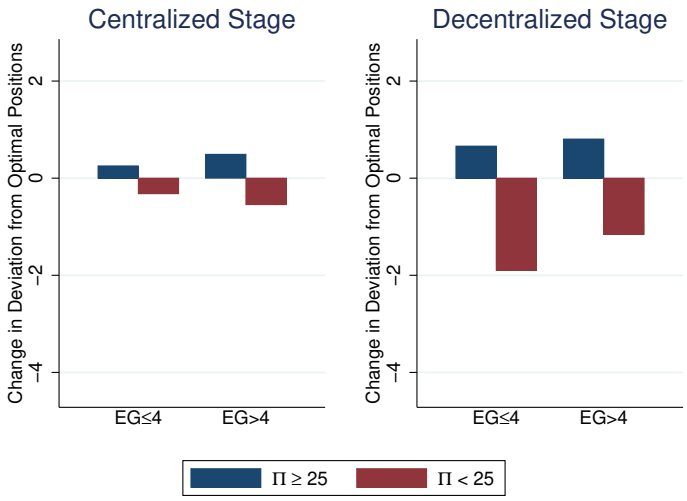
[18] Alternative specifications, such as verifiable mistakes and observed conflict, do not substantively change our results, though they do leave fewer observations, since mistakes and conflict outcomes may not be realized $ex-post$, particularly in low information environments. We also observe some agents using perfectly homogeneous teams as a strategy. In Appendix B.5 we analyze the main explanations behind this observed behavior.

Figure 16: Reactions to Prior Results in Initial Stages, by CRT Score



Notes. Average change in proximity to optimal positions in Centralized (left) and Decentralized (right) stages, by CRT score.

Figure 17: Reactions to Prior Results in Initial Stages, by Risk Tolerance

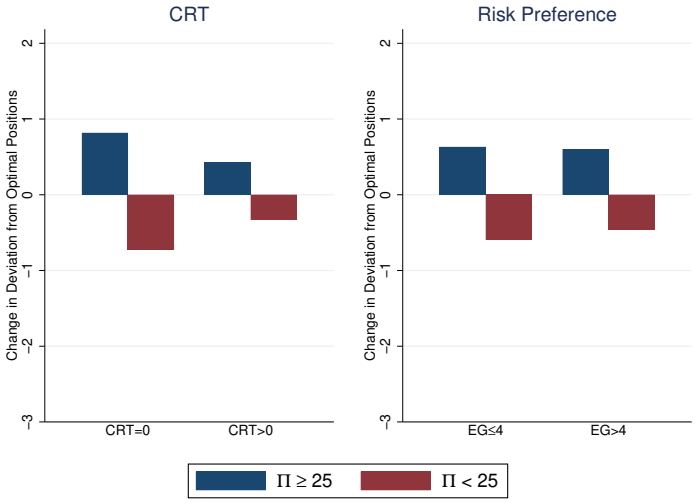


Notes. Average change in proximity to optimal positions in Centralized (left) and Decentralized (right) stages, by risk preference.

To further analyze the role of risk tolerance and cognitive reflection, we consider how often Managers change their organizational structure in the Selector stage. In aggregate, we see that there is no significant effect of CRT, but risk tolerant Managers change significantly less often. Figure 19 illustrates these changes differentiating between good and bad outcomes. First, both risk averse and impulsive Managers show no significant difference in their responses to good or bad outcomes. Second, risk tolerant and reflective Managers change significantly more in response to a bad result than a good one. Third, and most importantly, risk tolerant Managers make fewer organizational structure changes than any other group.[19]

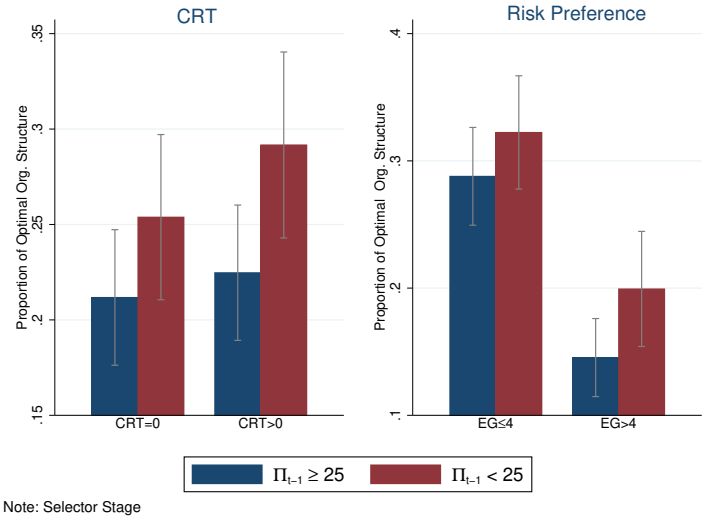
[19]We also find that Managers react to bad outcomes in the first two stages in determining their decisions in the Selector stage, reported in Appendix B.7. Managers who observed more outcomes that went against their preferences in the Decentralized (Centralized) stage delegated less (more) often in the Selector stage.

FIGURE 18: REACTIONS IN THE SELECTOR STAGE: TEAM SELECTION



Notes. Average change in proximity to optimal positions in all stages, by CRT score (left) and risk preference (right).

FIGURE 19: REACTIONS IN THE SELECTOR STAGE: ORGANIZATIONAL STRUCTURE



Notes. Average number of changes in organizational structure in the Selector stage based on prior round payoffs, by CRT score (left) and risk preference (right).

6 Discussion

Our results indicate how risk tolerance and deliberative thinking may aid managers outside the lab in successfully building adaptive organizations in uncertain environments. These characteristics interact in a nuanced, complementary way, suggesting that more of one may not necessarily offset a deficiency in the other. This complementarity operates on three identifiable levels. First, risk tolerance better enables managers to deal with highly uncertain environments, while deliberative thinking helps more when dealing with low uncertainty environments. Second, risk tolerance has a larger impact on the organizational structure decision (whether

to delegate), while deliberative thinking is more effective in driving team specialization (skill heterogeneity). Lastly, we identify two mechanisms that mediate the effect of these traits on organizational outcomes. Deliberative thinking helps managers make better initial decisions and to resist impulsive reactions regarding their team selection, while risk tolerance allows for more stability in delegating decision rights. In light of these findings, our organizational model and experimental framework may prove useful in offering further insight into efficient organizational function. Many other behavioral characteristics have been shown to impact decision making, such as overconfidence, assertiveness, and others. In addition to studying their direct effects on organizational outcomes, our design may allow us to identify how they interact with each other (for example, how might overconfidence moderate the impact of deliberative thinking?).

In section 5.4 we note that reputational concerns may induce cooperative actions by Workers. However, as shown in Appendix B.6, we find no consistent evidence for such behavior. We cannot say for certain what in our environment led to a lack of cooperative behavior among Workers, but two features in particular stand out. For one, Workers in our setting each have their own task to complete, and each task is independent of the other. In other words, our environment uses what Galbraith (1974) defines as self-contained tasks. How might behavior change as we introduce task interdependence, addressing open questions raised by Puranam and Raveendran (2013)? Additionally, Workers in our environment have stark incentives to focus only on the costs of completing their own task, leaving open the question of what incentives may be introduced to encourage cooperation such as those discussed in Kretschmer and Puranam (2008) and Dosi, Levinthal and Marengo (2003).

It may also be informative to consider refinements allowing workers to pick their own specialization. The question of human capital investment as an $ex-ante$ addition to our environment would provide interesting data on Worker beliefs (for example, do Workers think it will be more beneficial to have very specialized or generalist skillsets?). We could extend this to address issues like "on-the-job" training or career changes involving new skills entirely. To understand how workers adapt their specialization decisions to an organization's structure may help us understand the limitations a manager faces in controlling and allocating decision rights. Generally, a dynamic feedback environment between Manager decisions and the specialization selected by Workers would be interesting to explore.

Lastly, introducing communication, in conjunction with alternate task structures, might allow our environment to better inform other open questions in organization theory and organizational economics such as the formation and maintenance of transactive memory systems, or TMS (Brandon and Hollingshead, 2004; Ren and Argote, 2011). On a basic level, how might TMS play a role in the relationship between the allocation of decision rights and the specialization of independent or interdependent workgroups? In exploring these effects, it would be valuable to identify behavioral traits that play a role as antecedents to TMS development, and to what degree TMS mediates the impact of traits like deliberative thinking and risk tolerance on organizational efficiency.

7 Conclusion

Our study highlights the interrelatedness of personnel and organizational structure decisions in navigating uncertainty. It also shows how difficult managerial decisions can be when multiple facets must be considered at once. Given the prevalence of managers outside the lab who control both hiring and delegation, it is critical to understand this link and how it affects the adpative capabilities of organizations. To the extent that managers differ in their abilities, can we identify personal characteristics that may contribute to these differences?

To begin exploring these questions, we developed and experimentally tested a benchmark model of managerial decision making in which Managers chose their team's personnel and decision structure in concert. As in organizations outside the lab, we see substantial heterogeneity in decisions. While we see lower levels of delegation and more homogenous teams than predicted, we do find evidence that the benchmark model has explanatory power. First, Managers respond to growing task uncertainty by delegating more to their better-informed Workers. Second, average team specialization is independent of the level of uncertainty in decentralized organizations. Lastly, average team specialization is more heterogenous when the level of uncertainty decreases in centralized organizations. However, some Managers struggle with these decisions and do not appear to improve with experience. In the experiment, this costs them a sizeable amount in payoff reduction. Outside the lab, we may likely see worse results: individuals unable to effectively manage these tasks may not keep their job or receive a second chance.

Our data suggest that deliberative thinking and risk tolerance improve performance in this environment. Interestingly, these characteristics appear complementary, in that they impact different dimensions of managerial decision making. Reflective managers are able to resist impulsive reactions to probabilistically unlikely outcomes. Managers who struggle with making intuitive choices overreact to good and bad outcomes, and better quality feedback actually *exacerbates* the problem. Additionally, managers more willing to accept risk show greater willingness to delegate when optimal. These results reinforce a central issue that managers face; as they are tasked with making decisions under varying degrees of complexity and time pressure, the ability to reflect on each decision and take appropriate risks when facing uncertainty become even more important.

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