Making the Tough Choices: Delegation and Team Selection in Organizations*

John Hamman[†] Miguel A. Martínez–Carrasco[‡]

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Abstract

We model a managerial decision environment in which a manager both determines the skill heterogeneity of her workers and determines whether to retain or delegate the ability to allocate tasks. The manager prefers delegating when uncertainty is sufficiently high relative to the incentive conflict with her workers, which is endogenously determined by her chosen team composition. Experimental data supports the direction of the main predictions, though it shows how and why participants deviate from expected behavior. Generally, the results highlight the difficulties in navigating complex managerial environments and illustrate potentially costly ways in which managers seek to simplify their decisions.

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

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

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[†]jhamman@fsu.edu. Assistant professor, Department of Economics. Florida State University. Tallahassee, Florida, USA.

[‡]miguel.martinez@udep.pe. Assistant Professor, Department of Economics. Universidad de Piura - Lima. Lima, Peru.

1 Introduction

Two managerial decisions of paramount importance in any organizational setting are who to hire and how much control to retain over decision-making. A recent example highlights both of these decisions. When Twitter founder Jack Dorsey was faced with mounting challenges at his new firm, Square, he drastically changed his management approach. As an exposé in online news magazine "re/code" describes [Del Rey and Wagner, 2015], he decided to turn over decision making power to a newly created group of division executives, allowing him to focus on big-picture projects. To fill these positions, he invested immense amounts of firm resources in identifying and hiring top executives with highly specialized skills.[1] Generally, in choosing the skillsets of workers (which we refer to as team selection), managers must determine whether broadly skilled or highly specialized team members will most effectively complete their anticipated tasks. In navigating this issue, organizations spend significant resources on their hiring processes.[2] The managerial changes at Square highlight our central questions: just how closely linked are these two aspects of managerial decision making? Should more specialized teams always be given greater autonomy? What if the manager is uncertain about exactly what objectives the firm will have in the future?

Personnel decisions depend critically on whether the manager will have final say in key matters or delegate decision rights to workers (Dorsey would not have spent so much on high-powered executives had he not planned to give them decision-making power over their division-specific tasks). The delegation decision is nontrivial, particularly in rapidly evolving business environments where managerial uncertainty about the nature of future tasks may change. With high managerial uncertainty (that is, uncertainty over what future tasks may arise), a decentralized organization that allows workers to allocate tasks among themselves may be the best option. Intuitively, this enables rapid response to changing local conditions. However, the composition of the team and the nature of the decision play an important role on the final outcome of a decentralized organization. For instance, divisions with overly similar specializations may struggle with how to divide tasks due to skill overlap.[3] When incentive conflicts among workers or divisions reduce firm performance, the manager may prefer a centralized organization where she keeps control over all task allocation decisions.

Despite the potential benefit for firms in modeling this decision environment, the interrelatedness of worker selection and allocation of decision rights has not been directly addressed in the academic literature. We develop a simple model incorporating these decisions to study a general problem faced by firms - namely, the efficient completion of multiple tasks. We char-

[1] Another good example recently is the acquisition of the Washington Post by Jeff Bezos, CEO of Amazon.com. See, for example, [Stone, 2014] or [Blodget, 2013].

[2] See the PWC Saratoga 2013/2014 Human Capital Effectiveness Report. Blatter, Muehlemann and Schenker [2012] finds that for executive hires the search costs amount to over 4 months' wages of the new position. These costs are in addition to actual wages paid, and so highly competitive markets necessitate the ability to hire workers whose skill sets closely match a firm's need.

[3] For instance, the coordination problem among divisions inside Sony Corporation was a major reason behind its lost of leadership on the production of electronic devices. In 2012, intradivisional mis-coordination left Sony with a catalog of 30 different TV's, none of which could argue that they had the most cutting-edge technology [Tabuchi, 2012].

acterize the optimal combinations of team composition and allocation of decision rights under varying levels of managerial uncertainty. The key component in our model is the ability for the manager to select her team composition. This decision endogenously determines the degree of conflict among workers in a task allocation framework. It also determines the potential harm from a manager mis-allocating tasks across workers. We use varying team composition to proxy different skill sets or roles in a work group.[4]

We aim to capture a broad range of managerial decision-making by highlighting this critical link between employee makeup and the allocation of decision rights within a firm. For instance, a research division may decide which types of engineers to hire before all of its projects are known. A hospital administrator must often decide which type of doctors to staff in an emergency room without knowing what patients may arrive. Lastly, when a manager in a consulting firm hires a new team member there may be a high degree of future project uncertainty, though the team's organizational structure is already well defined. Moreover, the total cost of a project and the quality of the team's output will depend on task allocation among consultants and how the team's capabilities fit the project requirements. Our model may also inform the organizational decision making process after a merger between different firms, divisions or branches. The decision of which workers to retain and how to adjust the organizational structure is closely related to the new potential projects or tasks given to the newly merged firm. These vignettes all highlight the importance of team selection commonly faced in managerial decisions and its connection to an organization's level of decentralization.

The main intuition behind the model can be captured with a simple illustration: A more heterogeneous or specialized team allows the manager to better respond to a more dissimilar task profile in a centralized organizational structure. However, if the task uncertainty is very high, the manager may be unable to make an informed decision. To minimize the ex-ante impact of these mistakes, the manager prefers a team with greater overlap focused around the most common task addressed by the firm. On the other hand, in a decentralized organization, workers have perfect information about tasks but a potential conflict of interest may arise between workers and manager. Workers with similar specializations may have difficulty agreeing on the efficient division of tasks. The manager can reduce the potential incentive conflict by selecting a more heterogeneous team in terms of specializations.

Two main predictions from the model are worth noting here; for high or moderate levels of informational uncertainty, decentralization is the manager's optimal allocation of decision rights. Also, the worker types should be more heterogeneous under decentralized (as in the case with Square) than under centralized organizations regardless of the level of uncertainty. Worker types will converge under centralization as managerial uncertainty grows, but will be unaffected by the manager's uncertainty in a decentralized structure.

We test these predictions in a controlled laboratory experiment with three main results. First, we find that managers correctly delegate decision rights more often as information uncertainty

[4]Firms may change their allocation of decision rights and team composition, but those processes take time and resources, making the initial team composition and organizational structure decisions critical.

grows. However, we also find that there is a general tendency to centralize more than is optimal. So, while the response to uncertainty is in line with the model's predictions, our data suggest that managers may suffer from a "control premium," retaining allocation rights in low information conditions, which can be a costly decision [Fehr, Herz and Wilkening, 2013; Owens, Grossman and Fackler, 2014]. Second, we find that managers tend to select less specialized teams in centralized organizations than in decentralized, as predicted by the model. Teams are generally less heterogeneous than those predicted by the model, though they converge with experience toward optimal team composition. Interestingly, we find that team heterogeneity does not respond directly to the different levels of information but rather to the change in realized payoffs per round. As a consequence, the level of information indirectly affects team selection through team decisions in previous rounds. Lastly, we show that when managers observe that a worker's decision goes against their interest in previous rounds, they overreact by choosing a more homogeneous team in subsequent rounds. As uncertainty is reduced, this effect becomes more evident. In relation to this, the data are consistent with managers using fixed team compositions to simplify the delegation choice.

These findings together tell us much about how individuals in managerial positions may use team selection to help navigate uncertainty, but they also highlight the challenging nature of these environments. Even when managers successfully find an optimal team composition, a single unforeseen negative outcome can make them abandon their strategy. In doing so, they adopt strategies that may seem safer, but prove very costly. Many firm executives struggle with these decisions, and those who master them can expect greater likelihood of success. The difficulty, though, may be in sustaining profitable strategies over the long term when short-term losses arise.

The rest of the paper is organized as follows: We discuss related literature more thoroughly in section 2 before developing our theoretical model in section 3. Our experimental design and specific hypotheses comprise section 4 and we discuss our results in section 5. Section 6 introduces simulation results from a variant of the model to help explain our team composition effects and Section 7 concludes with general comments and discussion of further study.

2 Literature Review

Decision rights, incentive conflict, and adaptation: A rich theoretical literature in organizational economics studies the implications of modern property rights theory for the organizational structure within firms (e.g. Grossman and Hart [1986]; Hart and Moore [1990]).[5] Specifically, there has been a focus on how the allocation of decision rights affects a firm's ability to balance the trade-offs between "coordinated growth" (suggesting a centralized organization, as in Williamson [1996]) and rapid adaptation to local conditions, which favors a more decentralized organization as suggested by Hayek [1945]. These studies, like ours, develop models of incomplete contracts to derive predictions for when firms may benefit from centralized or

[5] Mookherjee [2006] provides a thorough overview of early work in this area.

decentralized decision making.[6]

A recent focus in this area has been the role of communication in helping firms manage the coordination-adaptation tension.[7] In a closely related theoretical paper, Dessein and Santos [2006] study organizations in which branches can change tasks to accomodate changing local tastes, but branch positions are fixed. The purpose of their study is to highlight the connection between communication technologies and adaptability. Other prominent theoretical examples are a closely related set of papers by Rantakari [2008] and Alonso, Dessein and Matouschek [2008, 2012], in which centralized firms may receive such distorted information that decentralization may be optimal even under situations with a strong need for coordination. Evdokimov and Garfagnini [2015] experimentally test a version of the models found in Alonso, Dessein and Matouschek [2008] and Rantakari [2008], and find results in line with the comparative statics of the model.

Brandts and Cooper [2015] experimentally test the behavioral assumptions behind many of these models; namely that divisions will successfully coordinate and that management will optimally utilize communication. They find that communication is not as strategic as predicted, and that managers struggle to optimally interpret communication. They also find that the coordination problem between divisions is non-trivial and leads to greater than predicted conflict.

Empirical studies of organizational structure are less common outside the lab due to identification challenges, though some important exceptions should be noted. McElheran [2014] finds that between-firm variation in decentralization is consistent with theoretical predictions based on the relative importance of adaptability or coordination within a firm. Thomas [2010], however, finds that adaptation to local preferences can lead to over-specialization of product lines at the expense of firm profits.

Our model differs from those mentioned above in several important ways. The primary distinction is that we endogenize the degree of coordination conflict by allowing the central manager to select her workers. To focus on worker selection, we exogenously determine the central manager's degree of informational uncertainty. This uncertainty is endogenous (though ambiguous) in Alonso, Dessein and Matouschek [2008, 2012] as well as in Rantakari [2008] and Dessein [2002].

Team Composition: Becker and Murphy [1992] theoretically establish that a more specialized team increases productivity, but it also increases the cost of coordination within teams. Other research shows that skill heterogeneity in manager-worker pairs [Mello and Ruckes, 2006] and beliefs heterogeneity among workers [Van den Steen, 2010] may affect willingness to delegate due to incentive conflicts. The main trade-off in our paper differs from the trade-off analyze in these studies. Our study explores efficient task completion within an organization when workers

[6] For example, several related articles study the tension in multi-divisional firms between task-specific managers and managers who oversee multiple tasks (Dessein, Garicano and Gertner [2010]; Hart and Holmstrom [2010]; Hart and Moore [2005]).

[7] This work largely builds off of early models of communication by Crawford and Sobel [1982], Bolton and Dewatripont [1994], and Dessein [2002].

are horizontally differentiated but vertically separated from management.[8]

Delegation and the "Control Premium": The theoretical literature on strategic delegation establishes many scenarios in which firm managers may optimize by ceding decision rights to a more well-informed agent, even in the face of incentive misalignment [Aghion and Tirole, 1997; Alonso and Matouschek, 2008; Hart and Holmstrom, 2010; Holmstrom, 1982]. Additional benefits for the delegator have been revealed in recent experimental research. For example Hamman, Loewenstein and Weber [2010] find that delegation enables principles to seek out a self-interested outcome at the expense of others without feeling responsible taking actions via intermediaries.[9] However, recent experimental studies have demonstrated that even in the face of beneficial delegation, many principals have difficulty in transferring their decision rights. For instance, Fehr, Herz and Wilkening [2013] find that principals retain decision rights far too often and over-exert effort in a delegation game. Similar newly released studies quantify this preference for authority - the "control premium" - in hierarchical relationships. Owens, Grossman and Fackler [2014] find that individuals prefer to rely on their own performance in a quiz than another subject, even when their probabilistic earnings are much lower. Controlling for ambiguity aversion and overconfidence, among other factors, they find a control premium of $8-15\%$ of expected net assets. Bartling et al. [2014] design a lottery selection game that allows them to quantify the degree to which individuals intrinsically value control of their decision rights. They find a control premium of around 16.7% that persists over a wide range of parameterizations.

The current project therefore fits nicely into the broad literature on decision rights in firms. We provide a test of the trade-off between adaptation and incentive misalignment in an environment that also enables us to identify the degree to which firm managers prefer to retain decision rights when it is not in their material best interest. We also contribute to the theoretical and experimental literature on delegation by examining one-to-many delegation rather than one-to-one. We next discuss the theoretical model in more detail.

3 The Model

We focus on organizations comprised of three members, a principal and two agents. The principal has a managerial role (manager) while agents have an operational one (workers). Worker heterogeneity is modeled by different specializations θ_i, and each receives a task t_i^0 to complete that period. The manager selects the worker's specialization, θ_i, which determines how costly

[8] Friebel and Raith [2010] highlights ways in which centralization affects the allocation of capital to projects proposed by well-informed division managers. Garicano [2000] focuses on the importance of knowledge acquisition and the cost of communication as determinants of task allocation inside a firm, while Garicano and Santos [2004] study how to match the tasks or projects with horizontally-differentiated talent focusing on market solutions but not on organizational ones.

[9] In a similar context, Bartling and Fischbacher [2011] and Coffman [2011] find significant reduction in punishment towards the principal when she delegates an unfair act, which is true even if the intermediary has transparently no decision making ability [Drugov, Hamman and Serra, 2014; Oexl and Grossman, 2013].

it is for the worker to complete t_i^0 for worker i.[10]

We assume that θ_i and t_i^0 have the same normalized support, $[0, 1]$. The original task realizations for each worker are independent and identically distributed based on the cumulative $F(t_i^0)$. The pair (t_1^0, t_2^0) determines the state of the world for the firm. We consider a task allocation framework where the manager wants to minimize the total cost of the firm defined by $\mathbb{E}\big[\sum_{i=1,2} C_i(t_i, \theta_i)\big]$, where $C_i(\theta_i, t_i) = |\theta_i - t_i^1|$ and t_i^1 is the final task assigned to the worker i.[11] Thus, the total cost to the firm increases linearly as the distance between the workers' abilities and their final assigned tasks increase. Critically, the manager and workers have imperfectly aligned incentives. We assume each worker receives a fixed payment that is high enough to cover her best outside option, where the firm strategically combines high wages with high dismissal rates as disciplinary devices [Shapiro and Stiglitz, 1984]. As a consequence the worker focuses on minimizing her cost, $C_i(\theta_i, t_i)$.

In this context, centralized organizations allow the manager to reallocate tasks. A decentralized organization, then, is one in which the workers decide unanimously whether or not to reallocate tasks. While the differences in objective functions may favor a centralized organization, the manager's information quality plays a critical role in the trade-off between organizational structures. In our model, we assume workers observe both tasks with certainty, but managers observe each task independently with some probability p known ex-ante by all agents.[12]

Critically, we also allow managers to choose the type of workers in their teams. Thus managers make two decisions before tasks are reallocated or not. First, the manager determines the organizational structure in her team by retaining or delegating reallocation rights. After this, she selects the team composition that will maximize her payoffs given the structure selected and the level of information available. The timing of the decisions in the complete model is divided in four stages 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. Workers observe both tasks.
4. The manager (centralized organization) or the team (decentralized organization) determines the final task assignment, (t_1^1, t_2^1).

In this game, each agent has a dominant strategy that we show using backward induction. First, we solve the manager's problem in a centralized organization and explain the main trade

[10]Firms are often able to distinguish potential employee skill sets but it is more difficult to recognize ex ante a worker's productivity. We abstract away from heterogeneous productivities and simplify the model by assuming that all tasks are completed at the end of the period.

[11]We assume both manager and workers are risk neutral. However, we obtain similar results with risk averse agents if we consider strict monotonically decreasing utilities as functions of the distance between positions and tasks.

[12] This captures the intuition that informational accuracy may differ across sectors or geographical locations. The differences in information accuracy can also represent the experience or ability of the managers.

off the manager faces. Then, we solve the manager's problem in a decentralized organization and underline the main incentive conflict between the manager and the workers. Finally, we compare the two organizational structures to determine the manager's optimal organizational structure given the level of information.

3.1 Manager's problem in a centralized organization

A manager may see one realized task, both tasks, or neither task, depending on p. Managers optimally respond to these different situations as follows:[13]

- If the manager observes both tasks, she reallocates tasks minimizing $\sum_{i=1,2} C_i(t_i, \theta_i)$.
- If the leader observes only one task, she would assign the task she observes to the worker with the closest position.[14]
- If the manager does not observe either task, she maintains the status quo (no reallocation).[15]

A manager without information ($p = 0$) is like a manager who cannot reallocate tasks. As a consequence, she will minimize the maximum expected distance each worker can face positioning them in the ex-ante expected tasks, $\theta_1 = \theta_2 = E[t^0]$. This somewhat trivial result becomes more interesting when we allow for task reallocation between workers. When there are reallocation possibilities and $p = 1$, the manager would not choose the same positions for both workers since reallocation can not change the final outcome with homogeneous workers. If the firm wants to take advantage of reallocation possibilities, the manager must select a more heterogeneous team. In particular, if we assume the distribution of each task is uniform, the optimal positions tend to $\theta_1 \approx 0.29$ and $\theta_2 \approx 0.71$.[16]

Figure 1 defines the probability that the manager decides to reallocate tasks as a function of p for all the possible states of the world, (t_1^0, t_2^0).[17] For this illustration, we analyze the case of two symmetric positions equidistant to $E[t^0]$ where $\theta_2 > \theta_1$. The shaded area represents the region where the manager would like to exchange tasks under perfect information. Since the manager does not always observe both tasks, she is likely to make some errors $ex-post$ in her task reallocation. Two types of errors appear as a consequence of the established rule. The

[13]A manager's optimal response is independent of initial task assignment in a centralized firm.

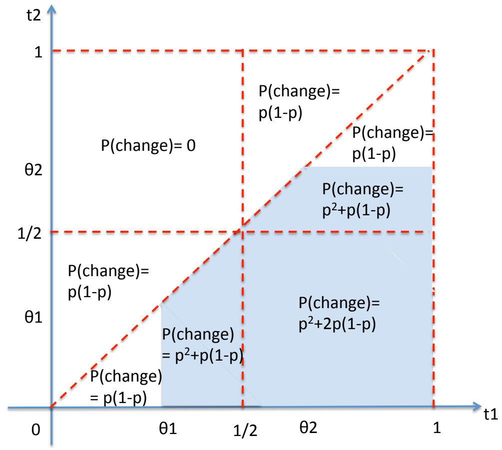
[14]This behavior is supported by the data we observe in the experiment. In 75% of the rounds where the manager observes exactly one task, she follows this behavior.

[15]Since managers have no information, any mixed strategy over the set of actions { Switch, No switch} would give us the same results. For simplicity, we assume a strategy assigning 0 to the *Switch* action and 1 to the *No switch* action - keeping the status quo.

[16]Intuitively, one can expect the solution to be closer to the values 0.25 and 0.75. That is true if we minimize the sum of the distance between the selected positions and the expected minimum/maximum tasks, $|\theta_1 - E[min(t_1^i, t_2^i)]| + |\theta_2 - E[max(t_1^i, t_2^i)]|$. However, our manager's problem is to minimize $E[|\theta_1 - min(t_1^i, t_2^i)| + |\theta_2 - max(t_1^i, t_2^i)|]$. Since, we are working with absolute value functions it is possible to show that both cases are not equivalent.

[17]The graph identifies the managers' probability to reallocate tasks given that managers are strictly better off following this strategy. If we include the situations where managers are indifferent, the probabilities on the upper right and lower left triangles become $p^2 + p(1-p)$ instead of $p(1-p)$. However, the final solution is unaffected by any of these approximations.

Figure 1: Reallocation Probabilities in a Centralized Organization



manager may fail to exchange tasks in a region where she would have preferred to do so (Type I error), and she may exchange tasks with some probability in the region where she would prefer not to change $ex-post$ (Type II error). Let $\delta(\theta_1, \theta_2) = \frac{\theta_2 - \theta_1}{2}$ be defined as the measure of heterogeneity of the team selected by the manager assuming that $\theta_2 \geq \theta_1$.[18]

Proposition 1 *For any p, if $t_i^0 \sim \mathcal{U}(0,1)$ for $i = 1, 2$, there is a unique $(\theta_1^C(p), \theta_2^C(p))$ in a centralized organization, such that:*

1. *$(\theta_1^C(p), \theta_2^C(p))$ are symmetric with respect to $E[t^0]$.*
2. *$\delta^C(p) > 0$ if $p \neq 0$.*
3. *$\delta^C(p)$ is a monotonic function of p*

See appendix for the proof. As expected, the manager prefers a more heterogeneous team if she expects to successfully enable the reallocation of tasks.[19] A poor information environment, though, increases the probability that the manager makes bad decisions. As a consequence, the manager will choose a more homogeneous group to minimize the impact of misinformation. An overly-homogeneous team, though, reduces the benefits of task reallocation. In a firm setting, if the information environment depends on manager expertise, our proposition states that a poorly-informed manager would prefer a more homogeneous team than an expert one in a centralized organization.

3.2 Decentralized organization and incentive conflict

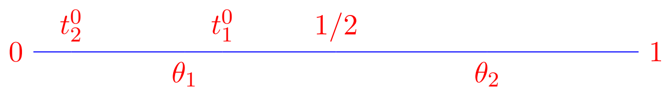
The manager's objective is unchanged in the decentralized organization. She must choose a team that minimizes the expected distance between workers' specialization and tasks. However,

[18]Notice $\delta(\theta_1, \theta_2) \in [0, \frac{1}{2}]$. The division by two is only for numerical tractability and it does not affect the results. Moreover, if we assume symmetric positions relative to the ex-ante expected task, we get: $\delta(\theta_1, \theta_2) = E[t^0] - \theta_1 = \theta_2 - E[t^0]$.

[19]Intuitively, the symmetry around the ex-ante expected task realization is natural since we assume a symmetric distribution and a worker's action on one side of the mean is a mirror of a equidistant worker's action on the other side.

workers now decide whether to reallocate the tasks, which may improve the reallocation of tasks due to workers having perfect information.[20] Critically, the workers' preferences are not perfectly aligned with the manager's preferences in this case. Because unanimity is required to reallocate tasks in the decentralized organization, either worker can unilaterally guarantee the status quo task assignment. We can therefore identify instances as in Figure 2 where the manager would like to exchange the tasks but one of the workers will not.

Figure 2: Main Incentive Problem in a Decentralized Organization



In this example, worker θ_1 minimizes her cost with her assigned task and will vote to not switch tasks. As a result no exchange takes place, though both other group members would have preferred reallocation. The reallocation of tasks in this case also maximizes the joint profits for the entire group.

Assumption 2 *There is no monetary transfer among workers.*[21]

Figure 3 highlights two symmetric areas where the manager would like to exchange tasks and one of the workers does not. The shaded triangle on the bottom left is the area where the worker in position θ_1 does not want to exchange tasks. The shaded triangle in the top right is the area where the worker in position θ_2 does not want to exchange tasks. Those areas are the graphical representation of the potential expected incentive conflict between the managers and the workers in a decentralized organization given (θ_1, θ_2). The shaded area considers the cases in which both workers decide to reallocate tasks.[22] The two downward-sloping diagonals in Figure 3 determining the area where workers reallocate tasks are parallel and they cross the 45 degree line exactly on the positions selected by the manager. If we assume that the manager chooses a more homogeneous team, those parallel lines get closer and the areas representing the incentive conflict grow larger. A manager can reduce the areas of conflict by choosing a more heterogeneous team, expanding the parallel lines outward. As a result, the members of the team exchange tasks more often. Since the manager affects the final results of the workers only through the positions selected, the optimal positions are independent of the level of information p. At the extremes, with a perfectly heterogeneous or homogeneous teams there is no conflict at all. In the decentralized organization, the optimal team composition is symmetric around the expected task and the distance between positions selected is constant for any value of p. The manager chooses a more heterogeneous team in a decentralized organization than in a

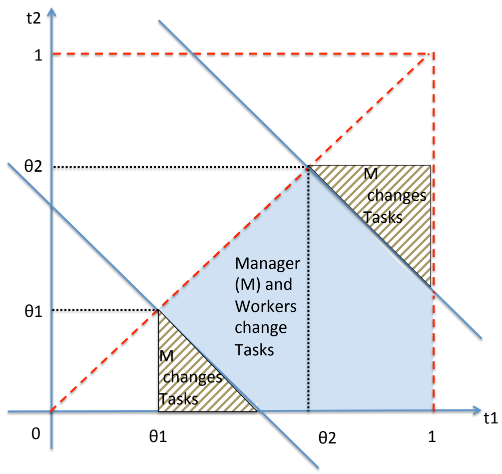
[20]Unlike in a centralized organization, initial task assignment plays an important role in the decentralized organization since both workers may want the same task. This may depend on experience, knowledge, rank or luck (e.g. project arrival). For simplicity, we assume tasks are randomly assigned. While other assignment rules may be interesting to study, they are beyond the scope of this paper.

[21]See Garicano and Santos [2004] and Fuchs and Garicano [2010] for market-based solutions to efficient matching. We focus here on organizational solutions where monetary transfers between members of the team are unlikely. For instance, when those transfers carry a reputational cost.

[22]The shaded area plus the two triangular areas pointed out previously denotes the cases where a manager with perfect information ($p = 1$) decides to reallocate tasks. We define these areas in the appendix.

centralized organization for all p.

Figure 3: Reallocation Regions in a Decentralized Organization



Proposition 3 *For any p, if $t_i^0 \sim \mathcal{U}(0,1)$ for $i = 1,2$, there is a unique $(\theta_1^D(p), \theta_2^D(p))$ in a decentralized organization, such that:*

- $(\theta_1^D(p), \theta_2^D(p))$ *are symmetric with respect to* $E[t^0]$.
- $\delta^D(p)$ *is constant* $\forall\ p \in [0,1]$.
- $\delta^D(p) > \delta^C(p)\ \forall\ p \in [0,1]$.

3.3 Optimal organizational structure

In this section, we integrate team selection into the manager's organizational structure decision to compare the expected profits generated by both solutions based on the level of information:

Proposition 4 *If $t_i^0 \sim \mathcal{U}(0,1)$ for $i = 1,2$, there exists a level of information p^* such that:*

- *If $p \geq p^*$, the manager prefers a centralized organization with* $(\theta_1^*, \theta_2^*) = (\theta_1^C(p), \theta_2^C(p))$.
- *If $p < p^*$, the manager prefers a decentralized organization with* $(\theta_1^*, \theta_2^*) = (\theta_1^D(p), \theta_2^D(p))$.

Proposition 4 states that the manager prefers to have the right to reallocate tasks among her workers when the level of information is "good enough." On the other hand, when the manager's information is poor, she prefers to delegate task reallocation rights to the workers. This result is not surprising and has been pointed out before in the literature. For instance, Dessein [2002] shows a similar result without team selection driven by the communication technology between the principal and the agents. However, we related this finding with the optimal team composition.

4 The experiment

Using a controlled laboratory experiment, we test the model's trade-off between the manager's information and her potential incentive conflict with her workers' decisions in order to respond effectively to randomly drawn tasks.

4.1 Experimental Design

We implement a hybrid between/within design where subjects were randomly assigned a role of Manager (M), Worker 1 (W_1), or Worker 2 (W_2) in three-person groups. Roles were denoted Participant A, Participant B1, and Participant B2 and the experiment was presented as one of decision-making instead of one of organizational decisions to avoid framing effects. In the experiment we consider a uniform distribution of the tasks over the support $[0, 100]$. We chose three different treatments, each capturing a different level of information. In the experiment, the probability p took one of the following values $[0.2, 0.5, 0.8]$. We do not choose a value of 1 for p to avoid that managers select always a centralized organization. This information would not reveal anything respect to the organizational preferences of the participants. Again, the body of experimental work on the control premium (among other topics) demonstrates that people are much more likely to sub optimally retain control than to sub optimally cede control. Thus, we select a value $p = 0.8$. Our design allows us to examine the behavior of subjects as they approach the information threshold but in environments that call for decentralization. By symmetry, we decide to have the treatment 0.2 and for completeness we include the treatment 0.5. Once determined, the probability of the manager seeing each task remained fixed within a session.

Each session was broken into three blocks of several rounds each. The first two allow the manager to familiarize herself with team selection in a centralized or decentralized environment, after which she enters a third block in which she decides both the team composition and now the organizational structure as well. This provides a stronger test of the model by giving subjects experience and feedback in both organizational structures before they must choose the organizational structure themselves.

Blocks 1 and 2 lasted 10 rounds each and were either Centralized or Decentralized (counterbalanced for each value of p). It was announced that groups would be fixed for each block with random rematching between blocks. The timing was as in the model. At the beginning of each round, subjects were reminded the value of p for the session and the role they were assigned. Then, managers chose the type of workers θ_1 and θ_2 by assigning each a "placement" between 0 and 100. Once the placement decision was made, the positions of W_1 and W_2 were fixed for the remainder of the round. Once both workers had been placed, the position of the tasks assigned to each worker were revealed. Workers saw both task positions with certainty, and were told which task had been matched to them. Managers saw each task position independently with the probability p for that session. Once the tasks were revealed or not to all group members, subjects completed a "switch" task. This task determined whether the workers would switch tasks or not. Subjects knew that workers and tasks could not be repositioned between 0 and 100, they could only switch which task was assigned to which worker. In the Centralized environment, the manager made the switch decision unilaterally, whether she saw one, both, or neither task position. In the Decentralized environment, workers voted over whether to switch. Only an unanimous vote to switch would result in a switch. If only one worker voted to switch, the tasks remained as initially assigned. After the switch tasks, payoffs were realized for all the subjects.

Payoffs in experimental currency (ECU) for group members were determined as shown in the equations below. It was possible, though improbable, for subjects to earn negative payoffs in a round. To minimize this risk, subjects received their total earnings collected over all rounds of the session and were reminded of this fact.

$$\pi_{W_i} = 50 - |T_i - W_i| \tag{1}$$

$$\pi_M = 50 - 0.5 \sum_i |T_i - W_i| \tag{2}$$

Where task T_i is matched with worker W_i at the end of the round. These formulas were explained to subjects with several examples, and subjects were given a calculation screen during the instructions with which to familiarize themselves with the payoffs (see the appendix for experimental materials including instructions and screenshots). The experimenter walked through an example at this time, with and without switching tasks. Once all subjects had some time to experiment with the payoff calculator, the experimenter made the following scripted comments to help ensure subjects knew how their decisions affected their payoffs: "What these payoff functions tell you is simply that you maximize your payoffs when you minimize the distance between each B participant and that participant's final marker. Note also that the A participant increases his or her payoff by minimizing the distance between each B participant and that participant's marker. Nothing in the payoff function depends on the B participants being close to each other or far apart from each other."

Once subjects 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 to her, 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.

Once blocks 1 and 2 concluded, subjects were read instructions for block 3, which we refer to as 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 the

Centralized or Decentralized environment. Specifically, the manager selected whether herself or the workers would complete the switch task for the round. Once the manager made this choice, she completed the placement decision and the round then mimicked either a round from block 1 or a round from block 2.

4.2 Procedure

We conducted this experiment in two locations. Initial sessions were run in the LEEX lab at Universitat Pompeau Fabra, and a second round of sessions were run in the xs/fs lab at Florida State University. Subjects were recruited using ORSEE ([Greiner, 2015]) at FSU and all sessions were run using the zTree software ([Fischbacher, 2007]). FSU sessions consisted of 24 subjects, and each subject received a \$10 show-up fee in addition to money accumulated from the game. UPF sessions had 21 or 24 subjects, with each receiving a €5 show-up fee. Sessions lasted just under two hours and average earnings were approximately \$24 and €16 (\$22) in the U.S. and Spain, respectively (exhange rates were 60 ECU per \$1 and 90 ECU per €1).

Instructions were first read aloud that included the value of p for the session (translated to Spanish for UPF by a native speaker also fluent in English), after which subjects were randomly assigned a role of Manager (M), Worker 1 (W_1), or Worker 2 (W_2) in three-person groups. Subjects were only read instructions for each block as it was reached, though they knew there would be three blocks from the beginning. They were also reminded (before block 1 and each subsequent block) 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 subjects were given the chance to familiarize themselves with placement selection and switching decision using the exact same screen they would see during the experiment.

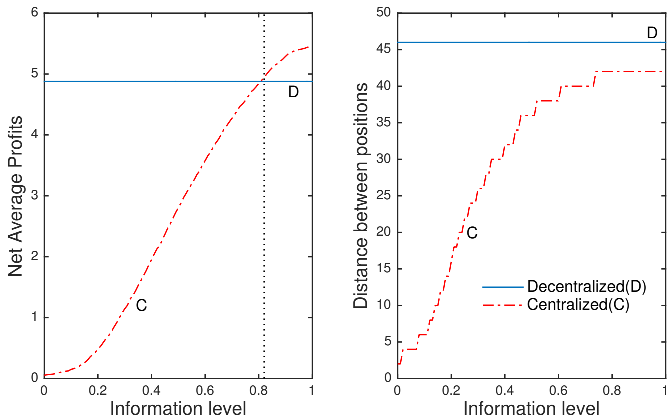
4.3 Theoretical predictions

Figure 4 represents a simulation of the main predictions under the previous assumptions of the model given the experimental design. We pursue a Monte-Carlo simulation with 100 managers playing 500 rounds for values of $p \in [0, 1]$. In the left hand panel, we plot the net average payoffs using equations 1 and 2 minus the expected payoffs obtained with a perfectly homogeneous "50-50" team. Notice 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 the 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.

Prediction 1 *In all treatments, the manager will delegate decision rights to the workers.*

In the right hand panel, 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 and positions $(29, 71)$ in the 80% treatment. In a decentralized organiza-

Figure 4: Payoffs and Team Composition Predictions



Notes. The figures summarize our main predictions. It shows the differences, as information quality increases, between expected profits by organizational structure (left hand figure) and team composition (right hand figure).

tion, the manager should select the position of $(27, 73)$ in all the treatments independently of the level of information. More generally, the predictions with respect to team composition are:

Prediction 2 *Team composition in a decentralized organization is always more heterogeneous than in a centralized organization for any level of information.*

Prediction 3 *In a centralized organization, the heterogeneity of the team increases when the accuracy of the manager's information increases.*

Prediction 4 *In a decentralized organization, the team composition is independent of the accuracy of the manager's information.*

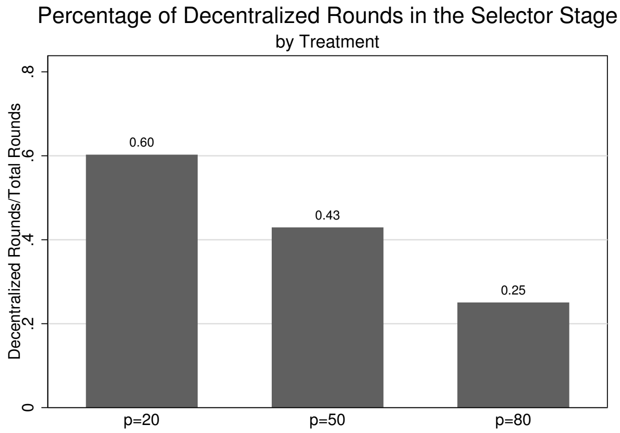
5 Experimental Results

5.1 Organizational Structure Decisions

Our first prediction is that managers will delegate in the Selector stage in all information conditions, since the threshold for centralized control (information probability of 0.82) is above our most accurate treatment. Figure 5 plots the percentage of rounds in which managers delegate in the Selector stage by treatment. The managers opt for decentralization more than sixty percent of the time in the 20% treatment (289 of 480 rounds). This drops to 43% in the 50% treatment (200 of 464 rounds) and 25% in the 80% treatment (120 of 480 rounds). The different proportions between treatments are significantly different (Pearson's chi-squared = 121.61; p=0.000). While managers do not delegate in all rounds, they do so significantly more often when facing poorer information. The threshold on the information level leading to the first prediction assumes that managers adjust their team composition optimally (their continuous control variable) while the organizational structure decision becomes a "yes" or "no" decision.

However, if managers have a predetermined team composition in mind before selecting their organizational structure, their optimal behavior more closely resembles the results on Figure 5. We explore this behavior further in section 6.

Figure 5: Delegation by Treatment



Notes. Plot of the percentage of decentralized rounds in the "Selector" stage. We had 30 managers in the 20% and 80% treatments and 29 managers in the 50% treatment for totals of 480, 480 and 464 rounds respectively.

To further support the finding in Figure 5, we implement the following logistic regression specification to control for additional factors:

$$Delegate_{ir} = \alpha + \delta_r + \beta_1 50\%_i + \beta_2 80\%_i + \gamma X_i + u_{ir}$$

where $Delegate_{ir}$ is a dummy variable equal to 1 if the manager i delegates in round r and 0 otherwise. δ_r is a set of round dummies and $50\%_i$ and $80\%_i$ are treatment dummies. Finally, X_i are participant controls and u_{ir} captures residual idiosyncratic determinants by participant i in round r.[23]

[23]The estimated coefficients of $50\%_i$ and $80\%_i$ are the mean differences with respect to the omitted 20% treatment. Standard errors are clustered by manager. Our main concern is the between-subjects effect of information quality in the Selector Stage. Adding fixed effects in the regression eliminates the most stable participant types that tend to play in line with the model's predictions. If we add fixed effects and drop the most stable subjects, effect sizes fall but remain significant. As a robustness check, we jointly cluster the standard errors of the coefficient estimates by round and treatment to avoid correlations of the residuals at the session level not captured by the round fixed effects δ_r. Finally, we implement a double clustering, by participant and round-treatment clusters. The main results do not change in any of these alternate specifications. These results are available upon request.

Table 1: Organizational Structure Decision: Probability to Delegate in Selector Stage

	Panel A: Full Sample			Panel B: Including Lags				Rounds 1-8	Rounds 9-16
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$50\%_i$	-0.701**	-0.958***	-0.962***	-0.924**	-0.947***	-0.556**	-0.592**	-0.791***	-0.416
	(0.35)	(0.36)	(0.36)	(0.36)	(0.35)	(0.26)	(0.25)	(0.26)	(0.29)
$80\%_i$	-1.513***	-1.822***	-1.829***	-1.842***	-1.897***	-1.238***	-1.319***	-1.474***	-1.193***
	(0.40)	(0.40)	(0.41)	(0.41)	(0.40)	(0.29)	(0.29)	(0.30)	(0.31)
$Payoff_{ir-1}$				0.009			0.005	0.010	0.001
				(0.01)			(0.01)	(0.01)	(0.01)
$Team.Heterogeneity_{ir-1}$					0.023***		0.020***	0.019***	0.020***
					(0.01)		(0.01)	(0.01)	(0.01)
$Delegation_{ir-1}$						1.914***	1.867***	1.633***	2.080***
						(0.29)	(0.28)	(0.30)	(0.31)
$Constant$	0.414*	-1.602***	-1.663***	-1.846***	-2.619***	-2.079***	-3.031***	-3.132***	-2.813***
	(0.25)	(0.58)	(0.61)	(0.63)	(0.72)	(0.53)	(0.61)	(0.64)	(0.63)
$RoundDummies$	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls_i$	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N. obs.	1424	1424	1424	1335	1335	1335	1335	623	712
N. clusters	89	89	89	89	89	89	89	89	89
Est. margin (mean):									
20%	60.2	64.1	64.1	64.0	64.2	55.5	56.2	58.6	54.3
50%	42.9	40.6	40.6	41.4	41.0	41.6	41.6	39.1	44.0
80%	25.0	22.4	22.3	22.0	21.2	26.5	25.6	24.5	26.5

Notes. * p< 0.1; ** p<0.05; *** p<0.01. Logit regressions with standard errors clustered by subject. $Treatment(p = k)_i$ is a dummy variable taking value 1 if the manager knows each of the tasks with a probability k. $Decentralization_{ir}$ is a dummy variable taking value 1 if the manager i delegates in round r, $Payoffs_{ir}$ are the payoffs per round in experimental currency obtained by subject i in round r and $Team.Heterogeneity_{ir}$ is the distance between positions selected by the subject i on round r. The controls by subject we are considering are the Eckel-Grossman risk aversion test, a cognitive reflection test, a dummy variable taking value 1 if Male, a dummy variable taking value 1 if the session was run in US and and a variable capturing different intervals of age.

Table 1 shows the regression results for different specifications of the baseline model, and the results are robust to many alternative specifications.[24] Consistent with Figure 5, both treatment coefficients are negative and significant. Moreover, the coefficient for $80\%_i$ roughly double that of $50\%_i$ in all specifications. We confirm the monotonic relationship from Figure 5, that more accurate information leads to higher rates of centralization, and the relationship grows stronger when we add demographic and risk preference controls as well as round dummies.

In Panel B, we attempt to distill the net effect by separating the direct effect of information quality on the manager's decision from the indirect effect of prior decisions. The decision to delegate is not affected by earnings from the previous round, but it is affected by the manager's previous decisions. Models 5 and 7 show that for every one unit change in the team heterogeneity, the log odds to delegate increase. The original treatment effects on the probability to delegate remained almost unchanged in model 5. This provides initial evidence of a weak relationship between team heterogeneity and the level of information, which we return to in the next section. Model 6 shows that the organizational structure decision in the previous round has a positive and significant effect on current decentralization that reduces the magnitude of the direct treatment effect.[25] Finally, in the two rightmost columns, we divide the sample between the first eight rounds played in the Selector stage (model 8) and the last eight (model 9). Model 8 shows that the direct effect is higher initially, compared to model 7, while the indirect effect is lessened. The opposite relationships appear in model 9, which suggests that managers successfully learn from their experience.[26]

We briefly explore whether we can identify underlying manager types that drive our Selector stage results. For instance, if we observe an increase of sixteen delegation choices, it could mean that half of the managers are delegating one more round or that one manager has delegated in every round. While the first example could be not taken as definitive proof of a change in behavior, the second is evidence of a change in the behavior of one subject. We classify managers into 3 different types based on how often they delegate. For simplicity, we classify a manager as a centralizer (C) if she decides to delegate in no more than four rounds of the "Selector" Stage. She is a neutral player (N) if she decided to delegate between 5 and 11 rounds

[24]We replicate these results using OLS and probit models. We also see the same results using random effects with bootstrapped standard errors. These are available upon request.

[25]Model 7 in Table 1 includes the lags of the team heterogeneity, delegation decision and payoffs. While it may raise some concerns about multicollinearity, we observe that all the correlations (Pearson's Correlation Test and Spearman's Rank Test) between these variables are positive but modest ($corr < 0.13$) in the Selector stage for managers. Moreover, the correlation between delegating and profits is not significant. In other words, there is sufficient variation across observations in the Selector Stage to obtain unbiased estimates.

[26]We find no gender differences in delegation, but delegating is positively and significantly correlated with risk seeking. We also see more delegation in the U.S. sessions than those run in Spain, significantly more in the 50% treatment. We include further location comparisons in the appendix.

and any manager decentralizing in at least 12 rounds is classified as a delegator (D). Table 2 shows the distribution of types by treatment.[27]

Table 2: Manager Types by Treatment

Classification/Treatment	20%	50%	80%	Total
D	13	5	3	21
N	10	13	9	32
C	7	11	18	36

Notice that there is a concentration of participants on the diagonal. There are more delegators in the 20% treatment, more neutral players in the 50% treatments and more centralizers in the 80% treatment. This relationship between treatment and manager type is highly significant (Fisher's exact test, p = 0.011). As a consequence, we confirm that the level of uncertainty clearly affects managers' propensity to delegate.

To summarize, our data show that managers clearly favor decentralization more with lower levels of information, which can be explained by a shifting mass of participants from being centralizers to delegators. Here, we join Evdokimov and Garfagnini [2015] to offer empirical support for this well-known theoretical result.

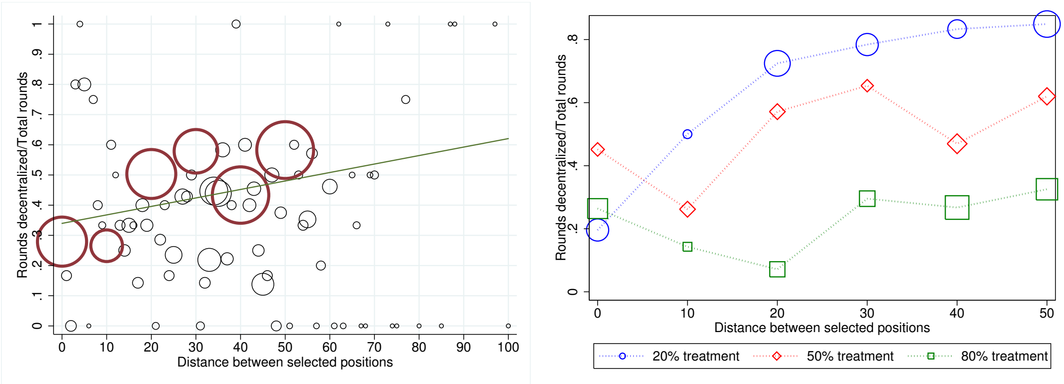
5.2 Team Composition

A brief overview shows that the average distance between positions in the centralized and decentralized stages is 29.83 and 29.40, respectively. On aggregate, then, we see no clear difference. In the selector stage, the average distance between positions in the centralized rounds is unchanged at 29.53, but this grows significantly to 33.16 in the decentralized rounds (Two-tail t test, $p = 0.0001$; Mann-Whitney two-tail test, $p = 0.0003$). This direction is in line with prediction 2, though not as high as predicted by the model. It also provides initial evidence that subjects may be learning to play more optimally with experience, at least in the decentralized rounds.[28] A pairwise test is suggestive but not conclusive given the repeated decisions made by each manager. We next explore more robust tests of the relationship between team composition, delegation and the level of manager uncertainty.

[27] These categories were selected based on the modes of the distribution of number of rounds decentralized by participant on the Selector Stage. See the appendix for a kernel approximation plot to those distributions and an alternate classification with five types.

[28] We use the distance between positions as a measure of team heterogeneity. It is also informative about the positions selected since most of the time those positions are symmetric.

Figure 6: Delegation and team heterogeneity



(a) Selector Stage: Full Sample

(b) Selector Stage: By Treatment

Notes. Panel (a) plots of the percentage of decentralized rounds in the Selector Stage (y-axis) by distance between worker positions (x-axis). The observations are weighted by the frequency of each chosen distance. The bold red bubbles represent the 63% of all the rounds played on the Selector Stage. The green line is a linear fit. Panel (b) plots the subset of the data representing 63% of all rounds played in the Selector Stage by treatment.

Panel (a) of Figure 6 plots the percentage of decentralized rounds by the distance between positions in the Selector Stage. We use the frequency of observed heterogeneity to weight each observation, represented by marker diameter. Sixty three percent of the sample is captured by the clusters shown in bold.[29] These clusters also contain 68% of the total number of decentralized rounds during the Selector Stage. The correlation shown by the linear trendline is approximately 0.1 and it is significant at the 5% level.[30] Panel (b) of Figure 6 plots these highlighted observations by treatment. There is a positive relationship between decentralization and team heterogeneity in all treatments, though we see level effects by treatment, as shown earlier in Figure 5. The main exception is when teams are perfectly homogeneous, where the organizational structure does not affect the final payoff.

These results show a positive and significant correlation between team heterogeneity and the tendency to delegate. We confirm this pattern using linear regressions with standard error clustered by manager, which are reported in Table 3.[31] Panel A shows that there is a strong relationship between delegation and team heterogeneity. Interestingly, the treatments have no direct effect on team heterogeneity once we control for the organizational structure. In Panel B we see that all lagged variables are positively and significantly related to team heterogeneity even when we consider them together. Notice that the lagged heterogeneity in model 5 removes

[29]The red markers represent 6 different values of the distance between positions: 0, 10, 20, 30, 40 and 50.

[30]We obtained a similar result using a Spearman rank correlation test.

[31]These regression results are not intended to argue a causal relationship necessarily, as managers may have determined their team heterogeneity based on intended organization structure or vice versa. What we do show is that the two decisions are clearly related.

the significant effect of delegation in the current round, while the lagged delegation decision in model 6 is significant but does not reduce the significance of the current delegation decision. This suggests that the prior team heterogeneity impacts current heterogeneity more than current delegation, while delegation itself has an additive effect over time.

From Table 1, we know that there is a relationship between the delegation choice and both the lagged delegation decision and lagged team heterogeneity. As a consequence, the observed relationship between heterogeneity and delegation in Table 3 is not unexpected. Comparing results from Table 1 and Table 3 highlights different drivers of these two decisions. Beyond the fact that both decisions depend on the lagged decision of the individuals, the decision to delegate depends on the treatments but not on lagged payoffs while for team heterogeneity the opposite is true. Finally, the last two columns split the selector stage in two halves. As in Table 1, we see evidence of learning. Model 8 suggest that agents are relying more on payoffs and their previous team heterogeneity decision since they may not have settled on their preferred organizational structure. Once they have determined their preferred structure, they do not rely further on prior payoffs but rather on their prior delegation decision (Model 9).

The dynamic nature of the experimental setting creates the dependence of workers' decisions on their history of play, which represents a challenge to simple interpretation of our coefficients. For a more conservative view, we regress each manager's average distance between positions in the Selector stage on the total number of delegated rounds chosen ($N.Dec.rounds$) in Table 4. The correlation between these two variables is positive and significant. In model 3, the impact of delegating one round more is associated with an increase in worker heterogeneity of 0.86, but when we split the Selector stage in half (models 4 and 5), we see that the relationship grows over time. This evidence suggests that the experience of managers reinforces the positive relationship between team heterogeneity and delegation. As before, the treatment has no impact on team heterogeneity. The evidence presented here generally supports prediction 2: managers are choosing more heterogeneous teams in decentralized groups. This allows them to minimize the potential for incentive conflict and encourages more frequent switching of tasks between workers.

Table 3: Team Selection: Distance between worker positions in Selector Stage

	Panel A: Full Sample			Panel B: Including Lags				Rounds 1-8	Rounds 9-16
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Delegate_{ir}$	4.384*	4.947**	4.987**	5.331**	1.432	4.141**	0.456	0.415	0.279
	(2.33)	(2.43)	(2.45)	(2.40)	(1.06)	(1.81)	(1.05)	(1.60)	(1.39)
$50\%_i$		1.427	1.436	1.377	0.629	2.024	0.905	0.728	1.204
		(3.31)	(3.32)	(3.25)	(1.29)	(3.31)	(1.28)	(1.62)	(1.41)
$80\%_i$		2.045	2.061	2.213	1.072	3.392	1.417	1.348	1.472
		(3.66)	(3.68)	(3.64)	(1.48)	(3.74)	(1.48)	(1.79)	(1.64)
$Payoff_{ir-1}$				0.144***			0.079***	0.137***	0.029
				(0.05)			(0.03)	(0.04)	(0.05)
$Heterogeneity_{ir-1}$					0.618***		0.612***	0.568***	0.653***
					(0.06)		(0.06)	(0.07)	(0.06)
$Delegated_{ir-1}$						3.437**	2.203**	1.109	3.281**
						(1.71)	(0.99)	(1.45)	(1.48)
Constant	37.292***	36.602***	37.955***	33.193***	13.129***	36.136***	11.419***	11.854**	9.616**
	(6.04)	(6.36)	(6.37)	(6.74)	(4.10)	(6.53)	(4.09)	(4.65)	(3.69)
$RoundDummies$	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls_i$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N. obs.	1424	1424	1424	1335	1335	1335	1335	623	712
N. clusters	89	89	89	89	89	89	89	89	89

Notes. * p< 0.1; ** p<0.05; *** p<0.01. OLS estimation with standard errors clustered by subject. $k\%_i$ are treatment dummy variables. $Delegate_{ir}$ is a dummy variable taking value 1 if the manager i delegates in round r, $Payoffs_{ir}$ are the payoffs per round in experimental currency obtained by subject i in round r and $Heterogeneity_{ir}$ is the distance between positions selected by the subject i on round r. The controls by subject we are considering are the Eckel-Grossman risk aversion test, a cognitive reflection test, a dummy variable taking value 1 if Male, a dummy variable taking value 1 if the session was run in US and and a variable capturing different intervals of age.

Table 4: Average heterogeneity for each manager in the Selector Stage

	All Sample			Rounds 1-8	Rounds 9-16
	(1)	(2)	(3)	(4)	(5)
$N.Del.rounds_i$	0.517*	0.661**	0.859**	0.728**	0.990***
	(0.27)	(0.30)	(0.35)	(0.36)	(0.37)
$50\%_i$			3.281	3.389	3.174
			(3.47)	(3.51)	(3.67)
$80\%_i$			5.428	5.038	5.817
			(4.14)	(4.03)	(4.45)
Constant	27.549***	36.957***	35.123***	35.708***	34.537***
	(2.54)	(6.10)	(6.51)	(6.49)	(6.71)
$Controls_i$	No	Yes	Yes	Yes	Yes
N	89	89	89	89	89

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. OLS with robust standard errors using one observation per manager. Using data from the Selector stage, we regress average team heterogeneity by total number of decentralized rounds with treatment dummies and demographic controls.

Centralized Rounds: The model's third prediction states that centralized teams should become more heterogeneous as the information improves, with the optimal distance between positions growing from 16 to 30, and to 42 in the 80% treatment. We see significantly more heterogeneity when comparing the 20% and 50% treatments (27.99 up to 32.56), but this disappears in the 80% treatment (as the distance falls to 29.04), as managers actually select *less* heterogeneous teams (we further investigate this "pinch effect" in section 6).[32] The pattern is true in both the centralized stage and in the centralized rounds of the selector stage.[33] While the aggregate results do not support prediction 3, a closer look shows some interesting behavior (figures can be found in the appendix). First, managers frequently select perfectly homogeneous teams, particularly in the 80% treatment, when heterogeneity is most beneficial *ex ante.* Aside from these observations, the modal team heterogeneity is very close to the optimal team predicted by the model - 20, 30, and 40 respectively as information accuracy improves. Moreover, the concentration of observations near the optimal values increases in the centralized rounds of the selector stage in the 80% treatment. In the 20% treatment, managers shift to more homogeneous teams in the selector stage, though there are notably fewer managers choosing centralization in this treatment. Another encouraging sign that managers are improving their team selection is that as we move from the centralized stage to the selector stage, we see fewer

[32]Teams in the 50% treatment are significantly more heterogeneous than in the 20% treatment (two-tail t test, $p = 0.0042$, M-W, $p = 0.031$).

[33]The variance falls significantly in the selector stages of the 50% and 80% treatments compared with the centralized stages, suggesting that managers are becoming more consistent in their team selection.

asymmetric teams in the 50% and 80% treatments.[34]

Decentralized Rounds: The model's fourth prediction states that a manager's information quality should not affect team selection for decentralized teams. In the decentralized stage, we again observe the "pinch" effect, in which the average team composition becomes more homogeneous as the level of information increases (average distance between positions are 32.43, 29.18, and 26.59 in the 20%, 50%, and 80% treatments, respectively).[35] In the decentralized rounds of the Selector stage, we see no such relationship. In the Selector stage, the level of information does not affect the selected positions, in line with the theoretical predictions. However, teams are overall more homogeneous than those predicted by the model.[36] We observe again a number of perfectly homogeneous teams in all treatments, even higher than in the centralized stage for the 50% and 80% treatments. However, in the decentralized rounds of the selector stage we observe a movement over rounds towards more heterogeneous teams in all treatments. As with the centralized rounds, we see stronger convergence in the selector stage towards the model's predicted distance between positions, which is 46 for all treatments under decentralization.[37]

We conclude, then, that managers fail to achieve optimal team composition on aggregate, regardless of organizational structure. However, we see clear signs of improvement as we move into the selctor stage, as experience helps most managers improve their decisions. The data are clouded some by managers who consistently choose perfectly homogeneous teams, but when we remove these from the sample we see modal behaviors closely in line with the model's predictions.

5.3 Manager payoffs

The interrelatedness of the organizational structure and team composition decisions make it difficult to disentangle the effect of each on subject payoffs. Comparing average earnings per round does not reveal much, as we see mean manager payoffs by treatment of 24.99, 25.25,

[34] A Two-sample Kolmogorov-Smirnov test shows that the distributions in the centralized stage and selector stage are different, though only in the 20% treatment is this statistically significant (p=0.003). Also included in the appendix are histograms showing distance between positions by treatment and by stage that illustrate the shifts between treatments and between stages.

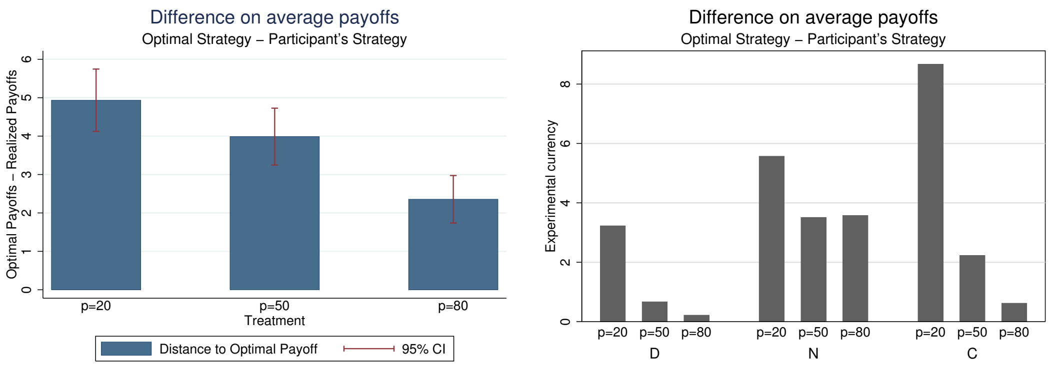
[35] Teams in the 20% treatment are significantly more heterogeneous than in the 80% treatment (two-tail t test, $p = 0.0006$, M-W, $p = 0.0016$).

[36] If we compare the decentralized stage with the selector stage, there is an improvement in team selection in all treatments but it is significant only in the 80% treatment (two-tail t test $p = 0.0058$; MW $p = 0.0085$).

[37] A Two-sample Kolmogorov-Smirnov test shows that the distributions of the decentralized stage and decentralized rounds of the selector stage are marginally statistically different between the 20% and 80% treatments ($p = 0.056$ and $p = 0.057$ respectively).

and 26.70 for the 20%, 50% and 80% conditions, respectfully. Not surprisingly, payoffs increase as information quality improves. However, we can see something informative by looking at counterfactual earnings from decisions in line with theoretical predictions (i.e. how much money they are "leaving on the table"). With known ex-ante optimal decisions and ex-post realizations, we calculate the payoff each manager would have earned in each round had she played the optimal decentralized strategy, and subtract the manager's realized earnings in the round. Panel (a) on Figure 7 shows this average difference in payoffs per round for managers in each treatment. All treatments are under-performing their optimal strategy, but the better information in the 80% treatment reduces under-performance relative to the 20% and 50% treatments.

Figure 7: Underperformance of managers relative to optimal strategy



(a) Selector Stage: All Sample (b) Selector Stage: By Treatment

Notes. Panel (a) plots the difference between the counter-factual payoffs that would have been obtained using the optimal strategy minus the actual payoffs realized by managers, separated by information condition. Panel (b) repeats the same analysis separated by manager type.

While Panel (a) on Figure 7 illustrates that managers are falling short of optimal payoffs on average in each treatment, it cannot identify the cause. Specifically, are managers earning less due to a failure to delegate or an error in team selection? Using the observed outcomes in each round of the selector stage to compare the hypothetical earnings from playing the optimal decentralized strategy versus a centralized strategy that used optimal team composition, we see a clear advantage in realized payoffs from delegating in the 20% and 50% condition, but it disappears in the 80% condition.[38] Using the optimal decentralized strategies the average payoffs per round per participant would be around 29 in all the treatments. Average payoffs using the optimal centralized strategies (a "second-best" benchmark) are increasing with the quality of information. Therefore, some of the under-performance seen in Panel (a) on Figure 7 must be due to team composition.

[38]The appendix shows a graphical representation of the of hypothetical earnings using optimal decentralized and centralized strategies given the observed outcomes.

Panel (b) on Figure 7 replicates the results from Panel (a), broken down by manager type.[39] All managers saw the worst performance in the 20% treatment, but performance generally improves as the information accuracy rises. Additionally, delegators come closest to their optimal benchmark in all treatments. Recall that the 20% treatment has the highest amount of delegators while the 80% has the lowest amount, as shown in Table 2. This highlights the interaction between uncertainty and organizational structure, as the learning process may be affected by the quality of information. Since managers saw fewer realized tasks in the 20% treatment, they had less information by which to adjust their strategy. Alternatively, there is a higher cost for the participants who do not delegate as the level of uncertainty increases, and so the feedback is less powerful in changing organizational structure in the 80% treatment.

These results fit qualitatively with prior findings on the control premium. It is costly when managers insist on having the final say in all decisions affecting their organization (in our case, selecting a centralized organizational structure). Furthermore, centralization is costly for neutral manager types in all treatments but it is more costly for centralizers when their information is poor. One way to derive an incomplete estimate of the control premium in our environment is by taking the difference between the optimal payoffs and the realized payoffs of delegators as the cost of a less heterogeneous team. Following this protocol, we see a control premium that ranges from 1% of the potential payoffs in the 80% treatment to 18% of the potential payoffs on the 20% treatment. Also, the cost of a less heterogeneous team is around 40 - 60% of this control premium estimate. Again, this evidence is merely suggestive and further analysis is needed, though it does match the range of control premium estimates observed in prior studies.

6 Understanding manager behavior

The unexpected behavioral patterns we identified in section 5 suggest that a closer investigation is needed. We specifically address two open questions regarding team selection raised by the data. The first issue we address is the "pinch effect," in which managers choose more homogeneous teams in the 80% treatment. The second issue first appears in regression results from section 5. Managers choose their team composition based on their prior experience, with information level playing no direct part. However, the opposite is true regarding their organizational structure decision. The level of task uncertainty, therefore, appears to affect team selection slowly and indirectly through a manager's decisions in prior rounds. This suggests

[39]In Figure 7, we omit participants who use the same position for both workers, since those participants are indifferent between the two types of organizational structures.

to us that managers may have a fixed team composition in mind before selecting between a centralized or decentralized organization. To explore this hypothesis , we solve a variation of the original model where managers take the team composition as fixed and select their organizational structure. Then, we simulate the results of this model and show that are very similar to those obtained in the lab.

6.1 Examining overly homogeneous teams: the "pinch effect"

We observe a curiously high number of perfectly homogeneous teams, particularly in the 80% treatment where agents have more information.[40] These observations explain much of the effect wherein managers reduce team heterogeneity as their information improves, and are remarkably common in both organizational structures. The repeated nature of the experiment allows us to identify a possible cause of this behavior. Participants seem to react strongly to "bad" outcomes in a round by changing their team composition in the following round. The occurrence of 50-50 teams is predominantly seen in these situations, though the direction of the manager's reaction depends on the positions they selected previously. To explore this effect we use the following linear regression (full results are omitted for space consideration):

$$dist\_pos_{(i,t)} = \alpha + \beta dist\_pos_{(i,t-1)} + \delta BAD_{(i,t-1)} + \gamma dist\_pos_{(i,t-1)} BAD_{(i,t-1)} + \mu_{(i,t)} \quad (3)$$

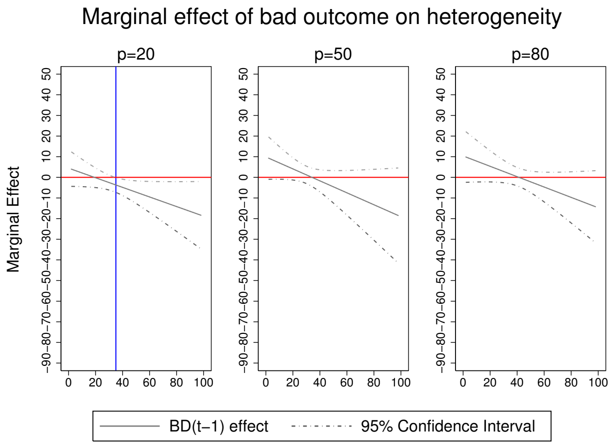
Where $dist\_pos_{(i,t)}$ is the distance between positions selected by participant i in round t, $BAD_{(i,t)}$ is a dummy variable equal to one if the payoff of the manager i in period t, π_{it}, is less than or equal to 25 and $\mu_{(i,t)}$ is an error term. We use this classification for "bad" outcomes, since 25 is the average payoff that a participant would receive if she takes the most conservative route of always choosing a homogeneous team at 50-50. Our sample focuses in the first two stages where participants could only select their team composition.[41]

Figure 8 plots the marginal effects of bad outcomes by distance between positions for each treatment in the centralized organization. The blue vertical line indicates ranges over which the effect is significant at the 5% level. In all treatments we see a pattern in which managers with more heterogeneous teams respond to bad outcomes by selecting more homogeneous teams. This is significant for the 20% treatment for distances above 35 and marginally significant (at the 10% level) in all treatments when the distance between positions is above 40. In the 20% treatment, this amounts to two fifths of decisions when the team composition is not perfectly homogeneous,

[40]See the appendix for a full categorization of the perfectly homogeneous teams.

[41] We focus on the cases when the distance between positions is not equal to zero in round $t-1$. However, the results using the full sample do not change.

FIGURE 8: REDUCED HETEROGENEITY: CENTRALIZED SSTAGE ($\pi_A \leq 25$)



Notes. Plot of marginal effects of earning less than 25 ECU (y-axis) by distance between positions (x-axis) for each treatment in the centralized stage with 95% confidence bounds. The vertical blue line separates the areas in the graph where we have significance effects from the areas where we do not.

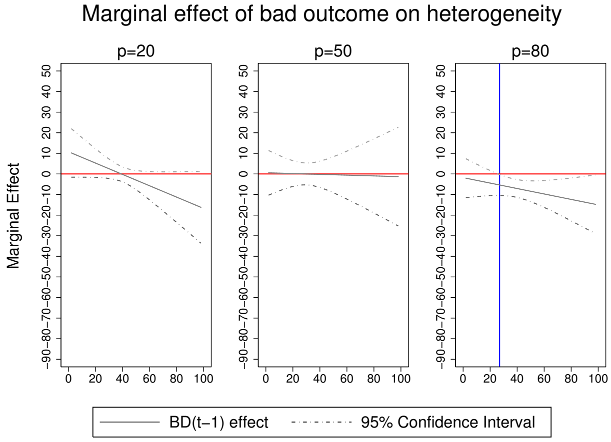
and one third of all decisions. Also note that managers with very homogeneous teams respond to bad outcomes by increasing the distance between positions. Recall that the optimal distance between positions in a centralized structure for the 20% treatment is 16. Therefore, the reaction could simply be managers learning to play the optimal strategy. We cannot rule that out, but the consistency of the result for all information levels suggests a broader reaction that can't be explained by the model.[42]

Figure 9 replicates this analysis for the decentralized stage of each treatment. We see the same negative trend in marginal effects in the 20% and 80% treatments. While the general trends are similar to what we see under centralization, we see clear changes in the x-intercept, particularly for the 80% treatment. The manager's reduction in team heterogeneity in response to bad outcomes now begins as low as 25 (compared to just over 40 in the centralized stage), which accounts for nearly half of all observations (more than 60% of observations if we ignore instances with perfectly homogeneous teams). In the 20% treatment, both the positive marginal effect for distances below 20 and negative effect for distances above 50 are perfectly in line with the theoretical prediction (the optimal distance is 46 regardless of treatment under decentralization). However, manager behavior in the 80% treatment is counter to the model.

What exactly is causing managers to reduce heterogeneity in response to bad outcomes? One

[42]Note that this phenomenon may be triggered by low payoffs even when managers play the optimal strategies as a consequence of the random realization of the tasks in the game. Although the likelihood of low payoffs when managers choose the optimal positions is lower, it may be enough to drive team selection away from the optimal strategy.

Figure 9: Reduced Heterogeneity: Decentralized Stage ($\pi_A < 25$)



Notes. Plot of marginal effects (y-axis) by distance between positions (x-axis) for each treatment in the decentralized stage with 95% confidence bounds. The vertical blue line separates the areas in the graph where we have significance effects from the areas where we do not.

explanation is that we are observing something akin to loss aversion (Kahneman and Tversky [1979]; Kőszegi and Rabin [2006]). However, the exhibited behavior is also potentially consistent with Selten's learning direction theory (Selten and Stoecker [1986]; Selten and Buchta [1999]), in which an errant behavior is corrected for by moving farther in the opposite direction to the prior wrong action. While learning direction theory cannot explain the fact that we see the strongest reactions in the direction of more homogeneity when this is further in the "wrong" direction from optimum, we cannot conclusively rule out either explanation.

In the appendix we consider an alternative measure for bad outcomes in the decentralized stage, where the workers' task reallocation decision was suboptimal from the manager's standpoint.[43] The results using this alternative measure show that the "pinch effect" is very robust and not driven by our choice to use realized payoffs less than or equal to 25. We again see significant and negative marginal effects in the 20% and 80% treatments very close to those reported above.

In the decentralized stage, team composition is the only decision made by managers. As such, managers who want to react to a bad outcome may do so by changing their team composition. Managers may think that increasing the distance makes it more likely that further bad outcomes will be seen, even though it also increases expected payoffs and reduces potential

[43] Although realized conflicts are intuitively appealing, there are many rounds (particularly in the 20% and 50% treatments) where the managers do not observe both tasks ex-post, and so cannot verify that a conflict of interest has taken place. In fact, the results are even stronger for the 20% treatment even accounting for the lower number of observations.

conflict with workers. Therefore, by narrowing the distance between positions the managers seem willing to forego expected earnings in order to avoid observing bad outcomes by controlling the one factor they can, in line with the literature on the control premium discussed earlier. This is more common in the 80% treatment because, with better information, managers more frequently observe the task positions and can therefore verify bad outcomes more often, particularly outcomes that result in a conflict of interest.

The reaction to bad outcomes plays an important role in team composition. It helps explain the high concentrations of 50-50 teams in the early stages of the experiment and the lack of heterogeneity in the final average positions. If we only consider cases of immediate reactions to a bad outcome (that is, one period later), we find that the effect can explain 30% of all observations of perfectly homogeneous teams. But, if we consider all rounds after a bad outcome in which the managers consecutively position their team at 50-50, the "pinch effect" can explain up to 50% of all observed homogeneous teams.

6.2 Fixed team composition

Given the challenge of the decision environment, it may be that managers try to simplify their problem by fixing their team heterogeneity and then deciding their organizational structure. We examine this possibility by adjusting the model to capture the cases where managers select their organizational structure under exogenously determined team heterogeneity.[44] This model represents situations that effectively limit the personnel options of a manager. The optimal allocation of decision rights under fixed team composition will give us a benchmark with which to compare the experimental results. The timing of the decisions in the game are now as follows:

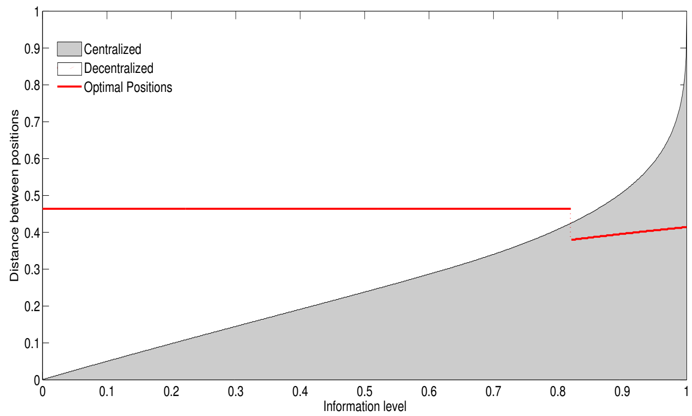
1. Workers have predetermined positions (θ_1, θ_2) and they receive a random task, (t_1^0, t_2^0).
2. The manager chooses either a centralized or decentralized organization.
3. The manager observes each task with an independent probability p. Workers observe both tasks.
4. The manager (centralized organization) or the team (decentralized organization) determines the final task assignment, (t_1^1, t_2^1).

Solving the model by backward induction, we obtain predictions for cost minimization in centralized and decentralized teams (see the appendix for details). We focus on symmetric

[44] With exogenously determined team composition, the model approximates a linear version of Alonso, Dessein and Matouschek [2008] without communication.

positions assuming tasks are uniformly distributed and compare the expected cost on both organizational structures. This comparison creates two distinct regions – One region where the decentralized organization dominates the centralized organization and second region where the opposite occurs. We identify these regions in Figure 10. On the y-axis we have the distance between selected positions in a symmetric team, with the level of information of the manager on the x-axis. The shaded area represents the combinations of team composition and level of uncertainty where a centralized organization minimizes cost and the white area denotes those in which the decentralized organization is preferred. The red line represents the optimal team composition given the level of information, which is discontinuous on the threshold level of p established in section 4.

Figure 10: Dominant Organizational Structure: Model Prediction



Notes. The figure identifies the organizational structure with the higher average profits given the predictions of the model on the team composition-level of information diagram. In the y-axis we have the team composition represented by the distance between selected positions (for symmetric positions around the ex-ante expected task). In the x-axis we have the level of information represented by the probability that the manager get information about each task. The centralized organization dominates on the shaded area and the decentralized organization on the white one. The red line represents the optimal team composition given the level of information selecting the optimal organizational structure. As groups become more homogeneous and manager uncertainty is reduced, centralized organizations gradually become payoff dominant.

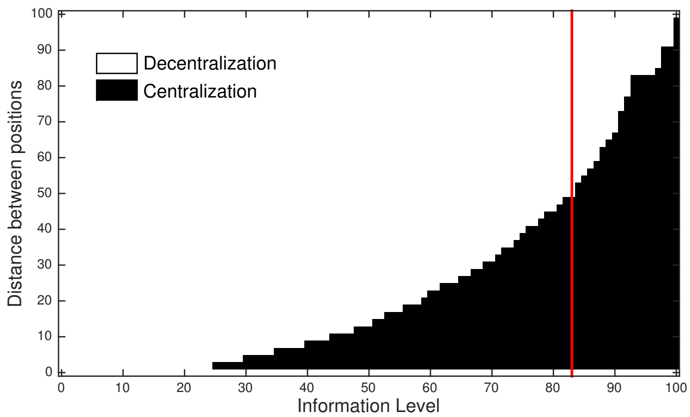
How would payoff maximizing managers allocate decision rights in this environment? To gain insight, we simulate 100 managers playing according to the model predictions over 500 rounds each. In each simulated round, the tasks are randomly drawn from a uniform distribution. We apply the reallocation rules for each organizational structure on a grid determined by the possible team compositions and level of uncertainty.[45] We then estimate the average profit per

[45]We focus on symmetric positions around the mean ($\theta_i + \theta_j = 100$ and $\theta_i - 50 = 50 - \theta_j$) covering all combinations from $(0, 100)$ to $(100, 0)$ with a 0.01 difference in each position by observation. We vary the level of information covering all values from 0 to 1 in 0.01 increments. This gives a grid with dimensions 101×101.

round at each point on the grid and compare centralized and decentralized teams.

Figure 11 identifies the regions on this grid where the simulated managers strictly prefer delegation. Unlike the case where a manager can choose her team composition, we do not see a constant threshold level of uncertainty determining which organizational structure is payoff maximizing. Instead we observe a convex frontier that separates the region where the decentralized and centralized organizations predominate, which is in line with our results in Figure 5 where delegation falls gradually as the level of information improves. This suggest that some participants may play as if they have some fixed positions in mind. It is also consistent with the experimental finding that the positions selected are not reactive to the treatment directly and adjust incrementally through prior realized payoffs.

Figure 11: Dominant Organizational Structure: Simulation



Notes. The figure identifies the organizational structure with the higher average profits from a Monte Carlo simulation with 100 repetitions of 500 rounds on the team composition-level of information diagram. In the y-axis we have the team composition represented by the distance between selected positions (for symmetric positions around the ex-ante expected task). In the x-axis we have the level of information represented by the probability that the manager get information about each task. The centralized organization dominates on the shaded area and the decentralized organization on the white one. As groups become more homogeneous and manager uncertainty is reduced, centralized organizations gradually become payoff dominant.

7 Conclusion

The change of Jack Dorsey's management strategy with Square highlights the interrelatedness of personnel decisions and delegation. It also shows how difficult managerial decisions can be when multiple facets must be considered. Given the prevalence of managers controlling both hiring and delegation, it is critical to understand this link.

To begin exploring this connection, we developed and experimentally tested a 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 managerial decisions. Managers tend to retain control of reallocation when delegation is in their best interest. We know from Fehr, Herz and Wilkening [2013] that this often leads managers to over-exert in other areas to make up the loss, which actually exacerbates the harm of centralized control! We do find some reassuring evidence: Although our managers delegate less than the model predicts, we see them respond to worsening task uncertainty by delegating more, in line with the model. We also see more diverse teams selected in decentralized versus centralized teams, as they should.

However, we find that managers react to negative outcomes by selecting disproportionately homogeneous teams, which is in line with loss averse behavior. When managers observe a worse than anticipated outcome, they overreact by choosing an overly homogeneous team in the following round. Better feedback actually *exacerbates* the problem. As uncertainty is reduced, the effect becomes more evident. While more research is needed to fully identify the mechanism, the behavior we see is certainly consistent with loss averse managers. To make decisions in this challenging environment, managers may rely on fixed teams to simplify their responsibility. Our simulations of fixed-position teams are consistent with this approach.

Our model is best seen as a first step in better understanding the complexities of managerial and organizational economics. We theoretically capture two important characteristics of managerial decision making and the data suggest that many of the tensions in the model have real impact on behavior. The experimental study also highlights just how difficult it can be to handle two such critical decisions. Many of the managers in our study do not learn with experience. In the experiment, this cost them a noticeable amount in payoff reduction. Outside the lab, we may even see worse results for many managers: most people unable to effectively manage these tasks may not keep their job.

The behavior of managers within an organization is a vital, though nuanced, topic of research. Our results highlight important ways in which personnel decisions interact with other managerial issues such as delegation. From here, we can begin to incrementally examine many additional - and equally important - elements of managerial decision making.

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