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Delegating Decisions to Organizations*

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Abstract

In strategic environments, a principal may increase her payoffs when she delegates decisions to an agent with exogenously or endogenously (e.g. via a contract) diverse preferences. We show that a principal can also increase her payoffs by delegating decisions to an *organization of agents* –i.e. to a group of rational individuals who interact according to a specified set of rules– *even when the agents' preferences are identical to those of the principal.* Arguably, this provides novel intuition regarding the contemporary structure of firms in several oligopolistic markets, where decision making is decentralized and the interests of agents and firm owners are, broadly speaking, aligned.

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1 Introduction

The main focus of the principal-agent literature in strategic environments is on the contracts that motivate an agent's actions, given a set of goals that the principal aims at fulfilling. In that respect, the typical paradigm involves a principal designing a contract that will incentivize agents to act optimally from the principal's perspective. Such contracts typically do not compensate the agent proportionally to the principal's payoffs –otherwise the principal would not need to hire the agent– and have been shown to be at times extremely sophisticated and involved (e.g. Lazear 2018). However, in reality it is not uncommon to observe rather simple contracts whereby employees of a firm are remunerated with stock options or ownership plans, i.e. their compensation is proportional to the firm's performance, and, hence, their interests are fully aligned with those of the principal.

On the other hand, the literature has often focused on relationships with exogenously given and relatively simple structures whereby one agent is assigned all the tasks that the contract designer would have to fulfill in the absence of an agent. Nevertheless, real-world principals may employ decentralized and elaborate structures to achieve their goals (Sengul et al. 2012). Indeed, in many instances principals (e.g. corporation owners) delegate decisions not to a single agent, but rather to an *organization of agents*; that is, to a group of agents who interact according to a well-defined set of rules. As Oliver Williamson stated "the modern corporation is formidably complex in its great size, diversity, and internal organization" (1981: 1539). For example, the R&D, the production, and the marketing operations may be both conceptually and physically (e.g. offshoring) decentralized in a world where global production chains and transnational companies are becoming increasingly common. While such organizations are designed and overseen by a common board, their complex structure requires a set of rules allowing various departments to operate with some degree of autonomy (e.g. Pitelis and Sugden 2000).

Hence, while analyzing the full spectrum of complex contracts that may emerge in simple principal-agent relationships is of great interest, it is equally important to study whether delegating decisions to complex organizations of agents remunerated by simple proportional contracts might also be beneficial for a principal. This is the task that we undertake in this paper.

We seek to understand how decisions are allocated inside an organization, or more generally speaking among a group of agents, what information is being exchanged inside the organization, and how individual decisions map into actions of the organization. We demonstrate that when two (or more) principals compete in a game, both may have interest in delegating decisions, each to two (or more) different delegates who share the same preferences with them. This allows the game to admit a larger set of equilibria, and in particular to obtain some outcomes that are Pareto-superior to the equilibria without delegation. Consider for instance a firm operating in an oligopolistic market and the distinction between allocating its decisions to an organization of agents, or a unitary agent. Strategically, these two forms of delegation are radically different. In the latter case, the unitary agent will play her best reply to any expected actions of the other firms in the market. In the former case, however, the organization's decisions will result from a mapping of all organizations' members' best responses, not only to the expected actions by the competing firms, *but also to the expected actions of the other agents within their own organization.*

In Table 1 we present an example of an abstract payoff matrix that helps one see clearly how delegating decisions to multiple agents can lead to better outcomes for everybody, and later on in the paper we will explain how similar situations can emerge in settings of applied interest (e.g. oligopolistic competition frameworks in which firms have to make decisions both regarding *R&D* investment and about production quantity).

Firm 2

Firm 1		A	B	**A**	**B**
	A	3, 3	3, 2	2, 2	1, 4
	B	2, 3	2, 2	2, 2	1, 4
	A	2, 2	2, 2	2, 2	1, 3
	B	4, 1	4, 1	3, 1	2, 2

Table 1: The payoff matrix of a game between two firms when each can choose an action from {A,B,**A**,**B**}. When each firm is managed by its owner the unique equilibrium outcome is (**B**,**B**). When each firm is managed by an organization of two agents –one deciding the letter of the firm's strategy and one deciding whether it should be bold or not– who are both remunerated proportionally to the firm's payoffs, then (A,A) is also an equilibrium outcome.

This paper is a first attempt to explore the consequences of the strategic interaction within organizations –or groups of players– in a generic setting. In the first stage players are allowed to create organizations by cloning themselves and by defining the rules of interaction among these clones, before playing a game against other organizations and/or unitary actors. We show that in the subgames with organizations, the set of equilibria is always at least as large as the set of equilibria of the game featuring only unitary actors. Moreover, in the subgames with organizations the "original" equilibrium of the unitary players' subgame is always preserved, while other equilibria may emerge. Importantly, delegating decisions to organizations will always be subgame perfect, including in instances where the game admits a Pareto-superior allocation to the equilibrium payoffs of the subgame with unitary players. Therefore, creating organizations is incentive compatible and might generate Pareto-superior equilibria that are absent from the game with unitary players.

We contribute to several strands of the literature on organizations that has primarily studied principal-agent relationships, optimal contracts, and the endogenous adoption of internal structures (e.g. Venkatraman et al. 1994, Mookherjee 2006). One specific feature of an organization consists in assigning tasks to teams of individuals to benefit from the members' differential abilities, the superior rationality of a group over individuals, or even from idiosyncratic group members' behavioral biases (e.g. Becker and Murphy 1992, Chen 1999, Brandts and Cooper 2006, Charness and Sutter 2012, Alonso et al. 2015). Our study complements these findings by uncovering the strategic consequences the creation of teams bears on the interactions with other decision-makers. von Stengel and Koller (1997) and Charness and Jackson (2007) also study teams evolving in strategic settings, yet our respective theories differ in fundamental ways. von Stengel and Koller (1997) consider the more specific case of an organization structured as a team confronting a unitary actor, and study one potential equilibrium emerging in such contexts, the *team-maxmin equilibria* whereby team members maximize the minimal expected payoff of their team when allowing for mixed strategies. We instead allow the competing agent to equally be a team (possibly of one agent), while we also show that the creation of such teams is incentive compatible, and thus emerges endogenously. Charness and Jackson (2007) resemble our approach in that they assume the organization's members to be endowed with the same preferences, the same objective functions, and a mildly complex structure since agents are unable to coordinate actions. On the other hand, however, Charness and Jackson (2007) do not study the wider consequences of the endogenous structure of an organization on the game's equilibria, a question of central interest in our paper.

Second, we expand the literature on the organizational theory of the firm, and more specifically on the optimal degree of delegation inside the firm (e.g. Holmström 1977, Holmström and Milgrom 1991). Building on the premise that the principal and the agent have non-aligned preferences and/or skills, scholars extended the benchmark model in several directions by considering multi-task organizations delegating part of the tasks to insiders (Riordan and Sappington 1987, Itoh 1994), by vertically (Battacharyya and Lafontaine 1995, and Romano 1994), or horizontally (Harris et al. 1982, Holmström 1982) organizing the subdivision of tasks. The above literature restricts the analysis to firms evolving in decision-theoretic environments. We instead view organizations strategically interacting with competitors, and demonstrate how delegation in such contexts enables players to improve their payoffs. While this result is reminiscent of the "strategic delegation" literature (e.g. Vickers 1985, Fershtman and Judd 1987, Fershtman et al. 1991), some fundamental differences ought to be underlined. In the "strategic delegation" literature firms have been shown to have incentives to vertically delegate decisions to an agent so as to pre-commit to an action the principal would rationally refrain from implementing. Key to the credibility of such commitment is the ability to write observable contracts (Katz 1991, Caillaud et al. 1995), even if the content of the contract is itself not observed (Fershtman and Kalai 1997, Kockesen and Ok 2004), for otherwise the principal would not be able to communicate his commitment to non-individually rational strategies. In this paper we demonstrate that for delegation to improve payoffs in strategic environments, agents are not required to have exogenously or endogenously (e.g. via contracts) different preferences from the principal. Instead, and in contrast to the strategic delegation literature, we allow for organizations to have complex structures that shape strategic interactions and the game's outcomes.

In the next two sections we develop our model and the paper's main theoretical contributions. Section 4 shows how delegating decisions to organizations leads to superior payoffs in a setting of applied interest, thus, establishing the empirical relevance of our theoretical argument. Lastly, Section 5 concludes.

2 The model

Consider a two-player normal form game involving player $\mathcal{A}$ with strategy set $S^{\mathcal{A}}$ and player $\mathcal{B}$ with strategy set $S^{\mathcal{B}}$. The payoffs of the two players at every strategy profile $(s^{\mathcal{A}}, s^{\mathcal{B}}) \in S^{\mathcal{A}} \times S^{\mathcal{B}}$ are given by $U^{\mathcal{A}}(s^{\mathcal{A}}, s^{\mathcal{B}})$ and $U^{\mathcal{B}}(s^{\mathcal{A}}, s^{\mathcal{B}})$ respectively. We will refer to this game by the term "original."

To study delegation to organizations we define a two-stage, six-player extensive form game such that in the first stage of the game delegation decisions are made and in the second stage of the game players engage in a simultaneous interaction that determines their payoffs. The set of players is $\{\mathcal{A}, A, a, \mathcal{B}, B, b\}$. The players named by calligraphic capital letters will be our "original" players –the principals– and players named by corresponding non-calligraphic letters will be their agents. In the first stage of the game the original players simultaneously choose their delegation strategies: player $\mathcal{J} \in \{\mathcal{A}, \mathcal{B}\}$ selects $\omega^{\mathcal{J}} \in \Omega^{\mathcal{J}} = \{(F; S, S')|F : S \times S' \twoheadrightarrow S^{\mathcal{J}}\}$. A delegation strategy –or an organization of agents– $\omega^{\mathcal{J}} = (F^{\mathcal{J}}; S_J^{\mathcal{J}}, S_j^{\mathcal{J}})$ is such that $(S_J^{\mathcal{J}}, S_j^{\mathcal{J}})$ are the strategy sets of J and j in the second-stage of the game, and $F^{\mathcal{J}}$ is a surjective function such that $F^{\mathcal{J}} : (S_J^{\mathcal{J}}, S_j^{\mathcal{J}}) \rightarrow S^{\mathcal{J}}$.

After the original players choose their delegation strategies, these choices become public knowledge and the other four players simultaneously choose a strategy from their corresponding strategy sets, $S_A^{\mathcal{A}}$, $S_a^{\mathcal{A}}$, $S_B^{\mathcal{B}}$, and $S_b^{\mathcal{B}}$. The payoffs of player $i \in \{\mathcal{A}, A, a\}$ at every strategy profile $(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}, s_B^{\mathcal{B}}, s_b^{\mathcal{B}}) \in S_A^{\mathcal{A}} \times S_a^{\mathcal{A}} \times S_B^{\mathcal{B}} \times S_b^{\mathcal{B}}$ of each second-stage subgame, are given by $U^{\mathcal{A}}(F^{\mathcal{A}}(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}), F^{\mathcal{B}}(s_B^{\mathcal{B}}, s_b^{\mathcal{B}}))$; and the payoffs of player $i \in \{\mathcal{B}, B, b\}$ at every strategy profile $(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}, s_B^{\mathcal{B}}, s_b^{\mathcal{B}}) \in S_A^{\mathcal{A}} \times S_a^{\mathcal{A}} \times S_B^{\mathcal{B}} \times S_b^{\mathcal{B}}$ of each second-stage subgame, are given by $U^{\mathcal{B}}(F^{\mathcal{A}}(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}), F^{\mathcal{B}}(s_B^{\mathcal{B}}, s_b^{\mathcal{B}}))$. That is, every original player has the same preferences as her agents on the game's outcomes. Therefore, when an original player decides to delegate power to only one of the agents (e.g. by employing a delegation strategy that involves a singleton strategy set for one of the agents), it is essentially as if she is not delegating decisions and keeps all decision making power to herself.

According to the above formulation, the "original" player $\mathcal{J} \in \{\mathcal{A}, \mathcal{B}\}$ essentially delegates a part of the decision to agent J and part of the decision to agent j, and shares the same preferences with both of them. Obviously, this is just a way to frame the problem that we are tackling and alternative formulations would make as much sense, and lead to identical results. For instance, we could have that the principal also participates in the the decision making stage. The important modelling assumption that is crucial for the analysis is not related to the identity of the players that participate in the second stage, but, instead, to the fact that the original player can shape the rules of interaction of decision makers with –exogenously or endogenously induced (e.g. via contracts)– similar preferences. Throughout the analysis, it will also become clear that all our arguments extend to an arbitrary number of original players and an arbitrary number of potential agents (at least two per principal), and the current assumptions regarding two original players and organizations composed of two players are only made to keep notation to a bare minimum.

For the original normal form game our solution concept is Nash equilibrium and for the six-player extensive form game our solution concept is subgame perfect equilibrium. Hence, when we use the term equilibrium with respect to the original game we mean Nash equilibrium and when we use it with respect to the six-player game we mean subgame perfect equilibrium. We note that an equilibrium of the original and of the six-player game is defined only with respect to the presented strategy sets, and not over their mixed extensions. Given the generality of our framework, this is not really a constraint since the sets might contain directly mixed strategies: i.e. probability distributions over some initial sets of actions.

3 Results

We begin by presenting an observation which will be the basis of the subsequent efficiency properties and incentive-compatibility of delegating decisions to organizations of agents.

Lemma 1 *Assume that the original game has an equilibrium* $(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$*. Then, every subgame of the six-player game admits a Nash equilibrium such that the payoffs of* $\mathcal{A}$*,* A *and* a *are* $U^{\mathcal{A}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ *and the payoffs of* $\mathcal{B}$*,* B *and* b *are* $U^{\mathcal{B}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$*.*

All proofs can be found in the Appendix.

This first result, while easy to establish, is of utmost importance in understanding the underlying intuition behind the analysis that follows. Among others, it guarantees that whenever the original normal form game admits a Nash equilibrium, the corresponding extensive form game admits a subgame perfect equilibrium. If we consider the immenseness of the sets of delegation strategies at the disposal of the original players in the first stage of the six-player game, the importance of this observation becomes apparent: when the original game possesses an equilibrium not only are we sure that the extensive form game admits an equilibrium, but we also have a lower bound of the maximum payoffs that can be achieved in a subgame perfect equilibrium.

All these allow us to state the following corollary to our first lemma.

Corollary 1 *Assume that the original game has an equilibrium. Then, a) every subgame of the six-player game admits a Nash equilibrium, and, consequently, b) the six-player game admits an equilibrium.*

We now turn to the main focus of our analysis; that is, the result that shows that delegation to organizations can improve the payoffs of the original players.

Proposition 1 *Assume that* $(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ *is an equilibrium of the original game and that* $(\dot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}})$ *is a strategy profile of the original game that Pareto dominates the equilibrium* $(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$*. That is,* $U^{\mathcal{A}}(\dot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}}) = U^{\mathcal{A}} \geq U^{\mathcal{A}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ *and* $U^{\mathcal{B}}(\dot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}}) = U^{\mathcal{B}} \geq U^{\mathcal{B}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$*, with at least one inequality being strict. Then, if there exists* $(\ddot{s}^{\mathcal{A}}, \ddot{s}^{\mathcal{B}})$ *such that* $U^{\mathcal{A}}(\dot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}}) \geq U^{\mathcal{A}}(\ddot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}})$ *and* $U^{\mathcal{B}}(\dot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}}) \geq U^{\mathcal{B}}(\dot{s}^{\mathcal{A}}, \ddot{s}^{\mathcal{B}})$*, there exists an equilibrium in our six-player game with payoffs* $U^{\mathcal{A}}$ *for players* $\mathcal{A}$*,* A *and* a *and payoffs* $U^{\mathcal{B}}$ *for players* $\mathcal{B}$*,* B *and* b*.*

This result proves that delegation to organizations of agents in certain contexts might be both incentive compatible and payoff-increasing. That is, the original players might choose to delegate their decisions to players with similar preferences as part of a subgame perfect equilibrium play, and also enjoy larger payoffs compared to the no-delegation benchmark. The core intuition of this result is that if there exists a strategy profile Pareto-dominating the Nash equilibrium of the no-delegation game, and if there also exists a deviation strategy from the Pareto-superior outcome that leaves the deviating party worse-off, then each of the original players can design an organization of agents such that, when all delegates choose actions that lead to the Pareto-superior outcome, the deviations of any agent will lead to the undesirable outcome, leaving everybody worse-off. This ensures that the Pareto-superior outcome can be reached at equilibrium. When these Pareto-superior outcomes are part of a subgame perfect equilibrium, it immediately follows that the threat of playing the Pareto-dominated Nash equilibrium in any other subgame implies that this organization of agents is incentive-compatible.

One should note here that while delegating decisions to organizations might generate Pareto-inferior equilibria in certain subgames –not always, but this possibility cannot be ruled out–, allowing principals to delegate decisions to organizations cannot give rise to a subgame perfect equilibrium with a Pareto-inferior outcome. This is so because if one of the original players believes that by delegating to an organization she will end up with a payoff that is inferior to the one that she would get in the original game, she can deviate and delegate decisions to a single delegate. Since, this guarantees that her payoff will be at least as high as in the original game, independently of the delegation strategy chosen by the other original player, it is straightforward to conclude that delegation to organizations might appear in a subgame perfect equilibrium, only if it helps both original players reach Pareto-superior outcomes.

4 An empirically relevant application

Knowing that delegation to an organization of agents can be part of a subgame perfect equilibrium and may enhance the payoffs of the players seems a potentially valuable theoretical result, but it is not clear from the preceding analysis whether it has empirically relevant implications or not. Indeed, the generality of the above framework and the constructive nature of the proofs cannot help us see in a transparent manner whether a payoff-increasing delegation strategy can be intuitive and, hence, realistic; or if all such strategies are mere theoretical artifacts.

To convince the reader that our theory bears important implications for environments of applied interest, we now revisit a widely known duopoly model and explore the consequences of allowing players to delegate decisions to organizations.

4.1 Noncooperative R&D in Duopoly with Spillovers

We consider a standard Cournot duopoly with two firms, $\{\mathcal{A}, \mathcal{B}\}$, each deciding their individual production $q_{\mathcal{J}} \in \mathbb{R}_{+}$, where $\mathcal{J} = \{\mathcal{A}, \mathcal{B}\}$, and facing an (inverse) demand $P(Q) = \alpha - \gamma Q$, where $Q = q_{\mathcal{A}} + q_{\mathcal{B}}$. We assume a cost function that allows for R&D spillovers across firms as in d'Aspremont and Jacquemin (1988), such that the production cost for firm $\mathcal{J}$ is given by $C_{\mathcal{J}}(q_{\mathcal{J}}, x_{\mathcal{J}}, x_{-\mathcal{J}}) = [T - x_{\mathcal{J}} - \beta x_{-\mathcal{J}}]q_{\mathcal{J}}$, with $T = 1 + \beta < \alpha$, $1/2 < \beta < 1$, and $x_{\mathcal{J}}, x_{-\mathcal{J}} = \{0, 1\}$. The binary variable $x_{\mathcal{J}}$ denotes the R&D investment decision of firm $\mathcal{J}$, and for simplicity we assume that firms need to incur a fixed cost K to achieve a unit level of R&D. We are thus assuming that if a firm invests in R&D, it benefits from a unit marginal cost reduction, while also reducing the marginal cost of its competitor by an amount $1/2 < \beta < 1$, with the lower bound on β being imposed for making our argument salient in this context, as will later become clear. A strategy for firm $\mathcal{J}$ is thus defined by $s^{\mathcal{J}} = (q_{\mathcal{J}}, x_{\mathcal{J}})$, and we accordingly denote a strategy profile by $(s^{\mathcal{A}}, s^{\mathcal{B}})$. Lastly, we assume that the level of R&D investments and the production quantities are decided simultaneously by both firms.

The original game

We begin by studying the "original" game involving two firms exclusively run by their owners, each taking two decisions, the R&D and the quantity production decisions, and in line with our theory we focus on the game's pure strategy Nash equilibria.

One possible equilibrium involves both firms investing in R&D. If both firms invest in R&D, the profit maximization problem of firm $\mathcal{A}$ reads as:

$$\max_{q_{\mathcal{A}}} \pi(q_{\mathcal{A}}, q_{\mathcal{B}}, x_{\mathcal{A}}, x_{\mathcal{B}}) \qquad s.t. \quad x_{\mathcal{A}} = x_{\mathcal{B}} = 1,$$

or,

$$\max_{q_{\mathcal{A}}} \left\{(\alpha - \gamma Q)q_{\mathcal{A}} - K\right\}.$$

Solving for both firms yields the following quantities, price, and profits:

$$q^I = \frac{\alpha}{3\gamma}, \qquad P^I(Q) = \frac{\alpha}{3}, \qquad \pi^I = \frac{\alpha^2}{9\gamma} - K.$$

For both firms innovating to be an equilibrium, we inspect whether firm $\mathcal{A}$ has an incentive to unilaterally deviate, in which case its profit maximization problem would read as:

$$\max_{q_{\mathcal{A}}} \left(\alpha - \gamma(q_{\mathcal{A}} + q^I) - 1\right) q_{\mathcal{A}},$$

And the associated profits after optimization are $\pi^{dev,I} = \left(\frac{2\alpha-3}{6}\right)^2 \frac{1}{\gamma}$.

Comparing π^I to $\pi^{dev,I}$, we deduce that both firms innovating is a Nash equilibrium if $K \leq \frac{4\alpha-3}{12\gamma} = \bar{K}$.

We next consider the conditions for no firm to invest in R&D at equilibrium. If no firm invests in R&D, the profit maximization problem of firm $\mathcal{A}$ reads as:

$$\max_{q_{\mathcal{A}}} \pi(q_{\mathcal{A}}, q_{\mathcal{B}}, x_{\mathcal{A}}, x_{\mathcal{B}}) \qquad s.t. \quad x_{\mathcal{A}} = x_{\mathcal{B}} = 0,$$

or,

$$\max_{q_{\mathcal{A}}} (\alpha - \gamma Q - 1 - \beta)q_{\mathcal{A}}.$$

Solving for both firms yields the following quantities, price, and profits:

$$q^{NI} = \frac{\alpha - 1 - \beta}{3\gamma}, \qquad P^{NI}(Q) = \frac{\alpha + 2(1+\beta)}{3}, \qquad \pi^{NI} = \frac{(\alpha - 1 - \beta)^2}{9\gamma}.$$

As above, for both firms not innovating to be an equilibrium, we inspect whether firm $\mathcal{A}$ has an incentive to unilaterally deviate, in which case its profit maximization problem would read as:

$$\max_{q_{\mathcal{A}}} \left(\alpha - \gamma(q_{\mathcal{A}} + q^{NI}) - \beta\right) q_{\mathcal{A}} - K.$$

And the associated profits after optimization are $\pi^{dev,NI} = \left(\frac{2\alpha+1-2\beta}{6}\right)^2 \frac{1}{\gamma} - K$.

Comparing π^{NI} to $\pi^{dev,NI}$, we deduce that no firm innovating is a Nash equilibrium if $K \geq \frac{4\alpha-1-4\beta}{12\gamma} = \underline{K}$.

Observe next that a symmetric pure strategy equilibrium always exists if $\underline{K} \leq \bar{K}$, which is easily shown to be true for any $1/2 < \beta < 1$.

Lastly, we inspect for the existence of asymmetric equilibria (denoted NS), which would imply one firm innovating, and the other not. Assume without loss of generality that firm $\mathcal{A}$ innovates and firm $\mathcal{B}$ does not. Optimizing the two firms' respective maximization problems yields the following optimal values:

$$q_{\mathcal{A}}^{NS} = \frac{\alpha + 1 - 2\beta}{3\gamma}, \qquad q_{\mathcal{B}}^{NS} = \frac{\alpha - 2 + \beta}{3\gamma}, \qquad P^{NS}(Q) = \frac{\alpha + 1 + \beta}{3}$$
$$\pi_{\mathcal{A}}^{NS} = \frac{(\alpha + 1 - 2\beta)^2}{9\gamma} - K, \qquad \pi_{\mathcal{B}}^{NS} = \frac{(\alpha - 2 + \beta)^2}{9\gamma} - K \qquad .$$

To determine whether asymmetric equilibria exist, we focus on the incentives for the innovator –firm $\mathcal{A}$– to deviate. Fixing $q_{\mathcal{B}} = q_{\mathcal{B}}^{NS}$ and optimizing firm $\mathcal{A}$'s profits when it deviates from innovating yields $q_{\mathcal{A}}^{dev,NS} = \frac{2\alpha-1-4\beta}{6\gamma}$ and associated profits amounting to $\pi_{\mathcal{A}}^{dev,NS} = \left(\frac{2\alpha-1-4\beta}{6}\right)^2 \frac{1}{\gamma}$. We therefore conclude that an asymmetric equilibrium cannot exist if $\pi_{\mathcal{A}}^{dev,NS} > \pi_{\mathcal{A}}^{NS}$, which is verified when:

$$K > \frac{4\alpha + 1 - 8\beta}{12\gamma} = K^{d\mathcal{A}}.$$

Proceeding similarly for firm $\mathcal{B}$, we can define a threshold value $K^{d\mathcal{B}} = \frac{4\alpha+4\beta-5}{12\gamma}$ such that firm $\mathcal{B}$ deviates from not innovating for any $K < K^{d\mathcal{B}}$.

Since $K^{d\mathcal{A}} < K^{d\mathcal{B}}$ for any admissible parameter values, it follows that for every $K > 0$, either $K > K^{d\mathcal{A}}$, or $K < K^{d\mathcal{B}}$ (or both). That is, at least one firm has incentives to deviate from the posited asymmetric strategy profile. Moreover, for $K > \bar{K}$, the equilibrium is unique and such that no firm invests in R&D.

The delegation game

We next consider the question of the endogenous creation of organizations –or delegation of some decisions to separate agents alongside a set of rules shaping their interactions–, and in this specific application we enquire whether the owner of a firm has incentives in delegating the R&D and quantity-setting decisions to separate agents. Denoting the agent in charge of setting quantities by capital letters and the one in charge of *R&D* decisions by lower case letters, we consider the following simple delegation strategy, D, which is such that: $s_J^{\mathcal{J}} = q_J \in \mathbb{R}_+$, $s_j^{\mathcal{J}} = x_j \in \{0,1\}$, and $F_D(s_J^{\mathcal{J}}, s_j^{\mathcal{J}}) = (s_J^{\mathcal{J}}, s_j^{\mathcal{J}})$. The non-delegation strategy, ND, is described by $s_J^{\mathcal{J}} = (q_J, x_J) \in \mathbb{R}_+ \times \{0,1\}$, $s_j^{\mathcal{J}} = \oslash$, and $F_{ND}(s_J^{\mathcal{J}}, s_j^{\mathcal{J}}) = s_J^{\mathcal{J}}$. The setting is the same as above, and we add a stage '0' where the *two* firms' owners, $\mathcal{A}$ and $\mathcal{B}$, take simultaneously the delegation decisions from $\tilde{\Omega}^{\mathcal{J}} \in \{D, ND\}$, a publicly observable action. Moreover, as in our general theoretical approach, we assume that the agents have the same preferences on the outcome space as the corresponding firms' owners.

Observe first that delegation, or the creation of an organization of agents, respects the model's setting since any strategy profile of the original game is reachable and, by extension, Lemma 1 and Corollary 1 are both true.

Suppose next –to make the problem salient– that $K > \bar{K}$. We then know from Lemma 1 that irrespective of which firms, if any, delegate decisions, the equilibrium outcome with no firm innovating survives.

Our aim is to inspect whether there exists an equilibrium with delegation that Pareto-improves the firms' payoffs. For the latter condition to hold there must exist a strategy profile of the original game that (weakly) Pareto-dominates the Nash equilibrium strategy of the original game. This is the case if $\pi^I > \pi^{NI}$, and $K > \bar{K}$. In other words, for delegation to Pareto-improve the firm's profits, we require that both firms innovating is not an equilibrium of the original game, while yielding higher payoffs to the players compared to the equilibrium without innovation. These two conditions are simultaneously verified if:

$$\frac{\alpha^2}{9b} - K > \frac{(\alpha - 1 - \beta)^2}{9\gamma}, \qquad \text{and} \qquad K > \bar{K},$$

Which simplifies to:

$$\hat{K} = \frac{(1+\beta)(2\alpha - 1 - \beta)}{9\gamma} > K, \qquad \text{and} \qquad K > \bar{K}.$$

Since $\hat{K} > \bar{K}$, there exist values of K such that the original game admits a unique equilibrium which is Pareto-dominated by the outcome where both firms innovate.[1]

To verify that a delegation equilibrium with both firms innovating indeed exists,

[1] This is indeed the case if $(5 - 4\alpha - 8\beta + 8\alpha\beta - 4\beta^2) > 0$, which is true for any $1/2 < \beta < 1$ and $\alpha > 1 + \beta$.

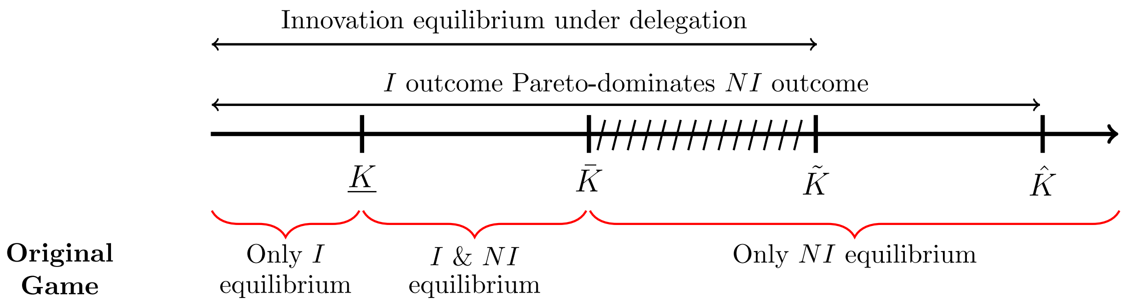

Figure 1: Pareto improving delegation equilibrium

we inspect whether either of the delegates –the one choosing the quantity, and the one choosing the R&D level– has incentives in deviating. There can be no profitable deviation in quantities since these have been chosen to maximize the firm's payoffs conditional on $x_j = 1$. The agent in charge of the innovation decision will not deviate from innovating if:

$$q_i^I(\alpha - 2\gamma q^I - 1) \leq \frac{\alpha^2}{9\gamma} - K = \pi^I.$$

And this reduces to:

$$K \leq \frac{\alpha}{3\gamma} = \tilde{K}.$$

We thus conclude that a Pareto-superior delegation equilibrium exists if $\tilde{K} > \bar{K}$, and that the range of K values for which such an equilibrium exists is defined by $K \in]\bar{K}, \tilde{K}]$. Figure 1 summarizes the information derived above, with the hashed area designating the area of interest.

Notice that in the subgames in which only one firm, or no firm chooses D, there is an equilibrium in which no firm innovates. By Lemma 1, it follows that both firms' owners delegating the decisions to separate agents in the first stage, both R&D

delegates innovating, and both quantity-setting agents producing q^I in the second stage, is a subgame perfect equilibrium that is sustained by reversion to the non-innovation equilibrium in case of deviation from simultaneous delegation in stage '0'. We can thus conclude that delegation generates a Pareto-superior equilibrium.

5 Conclusion

Contrary to common perceptions in the literature on contract design, maximizing the principal's payoffs does not necessarily require drafting elaborate agreements. By turning the attention to the internal structure of organizations, in this paper we have shown that Pareto-efficient payoffs can be attained even with extremely simple contracts where compensations are proportional to the organization's performance. The argument behind our finding is rather intuitive: complexifying the structure of an organization by delegating decisions to agents with a predefined set of rules shaping their interactions, expands the set of equilibrium outcomes. If this expanded set includes an equilibrium Pareto-dominating the one(s) of the game without delegation, this Pareto-superior equilibrium is then a subgame perfect equilibrium of the game with delegation. To better fix the ideas, we propose an application of our theory to a standard Cournot duopoly with positive R&D spillovers. We show that for some parameter configurations the unique equilibrium of the game is such that no firm invests in R&D, while allowing firms to delegate decisions to separate players gives rise to a Pareto-superior equilibrium where both firms innovate. Allocating the two strategic decisions to separate organization members who are both endowed with the same profit-maximizing objective function as the firms' owners, implies that a deviation from any given strategy profile is unidimensional (i.e. deviation in R&D *or* in quantities). Since this renders fewer types of deviations possible, the strategy profile where both firms invest in R&D becomes an equilibrium strategy profile in the subgame with delegation (complex organizational structure), while it is not in the alternative setting featuring a single decision-maker (simple organizational structure). In the specific context of this example, our theory casts new light on incentives to have separate R&D and marketing departments, an empirical regularity in several firms. From a wider perspective, our theory brings new insights on the commonly observed complex structure of organizations.

A Appendix

A.1 Proof of Lemma 1

Proof. In the first stage of the game, an original player, $\mathcal{J} \in \{\mathcal{A}, \mathcal{B}\}$, decides a delegation strategy, $(F^{\mathcal{J}}; S_J^{\mathcal{J}}, S_j^{\mathcal{J}})$, such that $F^{\mathcal{J}} : (S_J^{\mathcal{J}}, S_j^{\mathcal{J}}) \twoheadrightarrow S^{\mathcal{J}}$. Hence, for every admissible pair of delegation strategies, $(F^{\mathcal{A}}; S_A^{\mathcal{A}}, S_a^{\mathcal{A}})$ and $(F^{\mathcal{B}}; S_B^{\mathcal{B}}, S_b^{\mathcal{B}})$, there exists $(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}, \tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}}) \in S_A^{\mathcal{A}} \times S_a^{\mathcal{A}} \times S_B^{\mathcal{B}} \times S_b^{\mathcal{B}}$ such that $F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}) = \tilde{s}^{\mathcal{A}}$ and $F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}}) = \tilde{s}^{\mathcal{B}}$. Given that $(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ is an equilibrium of the original game it follows that $U^{\mathcal{A}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}}) \geq U^{\mathcal{A}}(s^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ for every $s^{\mathcal{A}} \in S^{\mathcal{A}}$, and $U^{\mathcal{B}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}}) \geq U^{\mathcal{B}}(\tilde{s}^{\mathcal{A}}, s^{\mathcal{B}})$ for every $s^{\mathcal{B}} \in S^{B}$. But since $U^{\mathcal{A}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}}) = U^{\mathcal{A}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}}))$ and $F^{\mathcal{A}}(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}) \in S^{\mathcal{A}}$ for every $(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}) \in S_A^{\mathcal{A}} \times S_a^{\mathcal{A}}$, it is the case that $U^{\mathcal{A}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}})) \geq U^{\mathcal{A}}(F^{\mathcal{A}}(s_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}}))$ for every $s_A^{\mathcal{A}} \in S_A^{\mathcal{A}}$ and $U^{\mathcal{A}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}})) \geq U^{\mathcal{A}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, s_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}}))$ for every $s_a^{\mathcal{A}} \in S_a^{\mathcal{A}}$. Similarly, we have that $U^{\mathcal{B}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}})) \geq U^{\mathcal{B}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(s_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}}))$ for every $s_B^{\mathcal{B}} \in S_B^{\mathcal{B}}$ and $U^{\mathcal{B}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, \tilde{s}_b^{\mathcal{B}})) \geq U^{\mathcal{B}}(F^{\mathcal{A}}(\tilde{s}_A^{\mathcal{A}}, \tilde{s}_a^{\mathcal{A}}), F^{\mathcal{B}}(\tilde{s}_B^{\mathcal{B}}, s_b^{\mathcal{B}}))$ for every $s_b^{\mathcal{B}} \in S_b^{\mathcal{B}}$. That is, every subgame of the four-player game admits an equilibrium such that the payoffs of $\mathcal{A}$, A and a are equal to $U^{\mathcal{A}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ and the payoffs of $\mathcal{B}$, B and b are equal to $U^{\mathcal{B}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$. ■

A.2 Proof of Proposition 1

Proof. Assume that $(\dot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}})$ is a strategy profile of the original game that Pareto dominates the equilibrium $(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$. That is, it is a strategy profile of the original game that gives weakly larger payoffs to both original players –strictly larger payoffs to at least one of them– compared to the payoffs corresponding to the equilibrium $(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$. Then, consider the following delegation strategy of player A: player A chooses an element from $S_A^{\mathcal{A}} = \{u, d\}$ and player a chooses an element of $S_a^{\mathcal{A}} = S^{\mathcal{A}}$.

If player A chooses $s_A^{\mathcal{A}} = u$ then $F^{\mathcal{A}}(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}) = s_a^{\mathcal{A}}$ except when $s_a^{\mathcal{A}} = \dot{s}^{\mathcal{A}}$. In that case $F^{\mathcal{A}}(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}) = \ddot{s}^{\mathcal{A}}$. If player A chooses $s_A^{\mathcal{A}} = d$ then $F^{\mathcal{A}}(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}) = \dot{s}_a^{\mathcal{A}}$ if player a chooses $s_a^{\mathcal{A}} = \dot{s}^{\mathcal{A}}$ and $F^{\mathcal{A}}(s_A^{\mathcal{A}}, s_a^{\mathcal{A}}) = \ddot{s}_a^{\mathcal{A}}$ otherwise. Notice that according to this simple delegation strategy: a) all strategies in $S^{\mathcal{A}}$ can be reached, and b) $\{d, \dot{s}^{\mathcal{A}}\}$ is a Nash equilibrium of the two-player restriction of the second-stage subgame to $F^{\mathcal{B}}(s_B^{B}, s_b^{\mathcal{B}}) = \dot{s}^{\mathcal{B}}$.[2] That is, the subgame in which $\mathcal{A}$ uses the posited delegation strategy and $\mathcal{B}$ a similar delegation strategy that leads to $\dot{s}^{\mathcal{B}}$ when the play of A and a are expected to lead to $\dot{s}_a^{\mathcal{A}}$, admits an equilibrium with payoffs $U^{\mathcal{A}}$ for players $\mathcal{A}$, A and a and payoffs $U^{\mathcal{B}}$ for players $\mathcal{B}$, B and b. If in all other subgames the original players believe that they will end up in equilibria with payoffs $U^{\mathcal{A}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ and $U^{\mathcal{B}}(\tilde{s}^{\mathcal{A}}, \tilde{s}^{\mathcal{B}})$ – the existence of which is guaranteed by Lemma 1 – then employing the described delegation strategies in the first stage of the game is part of a subgame perfect equilibrium. ■

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[2] Notice that when $(\ddot{s}^{\mathcal{A}}, \ddot{s}^{\mathcal{B}})$ is such that $U^{\mathcal{A}}(\dot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}}) > U^{\mathcal{A}}(\ddot{s}^{\mathcal{A}}, \dot{s}^{\mathcal{B}})$, then $\{d, \dot{s}^{\mathcal{A}}\}$ is a strict Nash equilibrium.

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