

Endogenous vs. Exogenous Leadership in Teamwork: An Socio-Economic Experimental Study

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Abstract. This paper presents the results of laboratory experiments designed to study the effectiveness of leadership as a way to improve efficiency in team production. In a three-player minimum effort game framework, the research compares either endogenous or exogenous leadership (in the former, the leader is chosen in an auction, and in the latter, the leader is randomly selected) with a control treatment where no leadership is considered. Although contributions do not seem to be significantly different between both leadership treatments, the effort levels found are in fact higher with exogenous (random) leadership than in the control treatment. Conversely, this effect is not found with endogenous (intentional) leadership.

Keywords: Leadership · Productive resources · Teamwork · Organizational designs · Control treatment

1 Introduction

When firms or organizations are stuck in a performance trap or free riding, the need for coordination is strongly required (Brandts, Cooper, Fatas, & Qi, 2015). Such mechanisms have been widely studied by game and behavioral theorists from several perspectives (C. Camerer, 2003). In team production, Holmstrom (1982) concludes that optimal outcomes cannot be achieved due to moral hazard problems under the following assumptions: (1) there exists a 'team' production technology; (2) productive resources belong to different owners; and (3) the value of the resource devoted by a member to the team is unobservable. In this framework, "there is no function of output distribution, differentiable, that induces individuals to achieve efficient team balance" (Holmstrom, 1982). Consequently, team members are not willing to supply the efficient level of their resources because the outcome of the team is shared among members, but the cost of the input is individually borne.

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At that point, organizational designs based on alternative conditions had been proposed as ways to improve team efficiency. For example, when the team is organized as a 'classical capitalistic firm' collective production activity can reach higher efficient levels (Alchian & Demsetz, 1972). From this view, efficiency can be restored under several assumptions: 1) the existence of a 'monitor', who has the right to agree with the members of the former team on their respective contributions as well as on their earnings; 2) this 'monitor' holds the residual claim as an incentive to guarantee the optimal design of the contracts with the owners of the inputs. Different solutions have been proposed to the inefficiency problem in teams through the implementation of optimal incentive systems (Holmstrom, 1982), contracts (Milgrom & Roberts, 1987), and leadership (Hermalin, 1998).

Leadership is a prominent alternative for solving coordination problems (Arce M, 2001; R. Cooper et al., 1994; Foss, 2001). Nevertheless, previous studies in leadership focused on corporate culture (Kreps, 1990) and the role of environmental contingencies in leadership styles (Rotemberg & Saloner, 1993), among others.

2 Antecedents

Previous studies reveal the relevant role of leadership in team performance (Bass & Stogdill, 1990). Effective leaders are characterized by their ability to coordinate the actions of team members through the successful communication of common goals (Bolton, Brunnermeier, & Veldkamp, 2010). Effective leadership processes represent one of the most critical factors in the success of organizational teams (Zaccaro, Rittman, & Marks, 2001). These findings encourage us to look into organizational designs based on leadership viewed as a potential solution to the inefficiency of teams that relies more on the leader's 'informal authority' (Aghion & Tirole, 1997; Gerth & Mills, 1946) than on hierarchical structures that could lead team members to substitute their criterion of individual utility for collective utility.

Leadership and teamwork are strongly related. On the one hand, leadership is about selecting a goal and making others follow this goal (Gardner, 1993), and its effectiveness depends heavily upon how much "*a leader convinces followers that she is not misleading them*" (Kotter, 1996). On the other hand, teamwork is positively related to performance and particularly to productivity (Delarue, Van Hootegem, Procter, & Burridge, 2008). The leader may also be viewed as a "coach" in teamwork (Rosner, 2001).

Experimental methodology has contributed to testing a wide variety of theories on economic behavioral issues, like the analysis of individual decisions (Von Neumann & Morgenstern, 1944), prospective theory (Kahneman & Tversky, 1979), theory of the generalized expected utility (Ormiston & Quiggin, 1993), among others. However, as its known, the effect of elected leadership on teamwork and its effects regarding coordination issues have been ignored in experimental studies.

This paper fills this gap by suggesting an experimental design based on the so-called Minimum Effort Coordination Game (MECG) agent's utility functions. Next, its defined the model proposed to test the differential effects of random versus intentional leadership on team production.

3 Theoretical Results

This section reviews the model of team production and its theoretical predictions, according to Holmstrom's definition of team production. The theory is summarized by the following assumptions: (1) The feasible production set is represented by a production function, $y = F(\vec{a})$, where y is the output value and $\vec{a} = (a_1, a_2, .., a_N)$ the vector comprising each member's contribution; (2) Production function $F(\cdot)$ holds the property of 'team technology', which implies that individuals, given the same level of input, can obtain a higher level of output if they participate in the team than if they do not; (3) each member owns one and only one input and hence, a_i is the contribution of member i; (4) each member bears the cost to allocate his resource to the productive activity of the team, $V_i\ (ai)$, where $Vi\ (\cdot)$ is an increasing and convex function in ai for all i. Therefore, the net profit or surplus of the team will be given by $U(\vec{a}) = \mathrm{F}(\vec{a})-$; (5) the utility function of the member i of the team is $U_i = \mathrm{S}_i(y) - V_i(a_i)$ for $i = 1, 2, \ldots., N$, where $S_i(\cdot)$ is a rule on the output distribution or, in other terms, the compensation function that depends exclusively upon the output of the team (y); (6) any member can obtain a utility of zero if she leaves (or she does not join) the team.

Given the above assumptions, efficient and Nash-equilibrium solutions are described as follows.

3.1 Efficient Solution and Nash Equilibrium with no Leadership in the Team

Pareto-efficient solution to the team problem is given by:

$$\max_{a_i} \sum\nolimits_{i=1}^{N} U_i = y - \sum\nolimits_{i=1}^{N} V_i(a_i) \tag{1}$$

such that: $U_i = S_i(y) - V_i(a_i) \geq 0,\ \ for\ i = 1, 2, \ldots, N$

$$y = F(a_1, a_2, .., a_N)$$

$$a_i \geq 0,\ for\ i = 1, 2, \ldots, N.$$

The first order conditions (FOC) of the above problem are:

$$\frac{\partial F}{\partial a_i} - \frac{dV_i}{da_i} = 0\ for\ i = 1, 2, \ldots, N. \tag{2}$$

Thus, the efficient solution to the team problem is achieved when the marginal revenue of each productive resource equals its marginal cost.

However, the maximizing problem of an individual member is quite different from the above since each (selfish) individual would seek to maximize her own utility, given the contributions of the other team members, i.e.:

$$\max_{a_i} U_i = S_i(y) - V_i(a_i)$$

s.t.: $U_i = S_i(y) - V_i(a_i) \geq 0,\ \ for\ i = 1, 2, \ldots, N$

$$\sum\nolimits_{i=1}^{N} S_i(y) \leq y$$

$$y = F(a_1, a_2, .., a_N)$$

$$a_i \geq 0, \ for \ i = 1, 2, \ldots, N.$$

The FOC to the above problem are:

$$\frac{dS_i}{dy}\frac{\partial F}{\partial a_i} - \frac{\partial V_i}{\partial a_i} = 0 \ for \ i = 1, 2, \ldots, N. \tag{3}$$

The inefficiency of the above Nash equilibrium becomes clear as the term $\frac{dS_i}{dy}$ is always positive but lower than one.

3.2 Nash Equilibrium with Leadership in the Team

Let us assume now that team members take into account the information delivered by the member i of the team, will be called 'the leader'. The leader decides her own contribution in order to maximize her utility. She also knows that her decision will determine the contributions of the remaining members, or 'followers' which are determined by a $N - 1$ vector of 'reaction functions' that characterizes the contribution of member j ('follower') as a deterministic response to the leader's choice, namely, $a_j = \phi_{ij}(a_i)$. Other assumptions of the model remain unchanged. Then, the variation in subject j ('follower') contribution due to changes in the contribution of subject i (the leader) contributions is:

$$\frac{da_j}{da_i} = \frac{d\Phi_j}{da_i} \ for \ j = 1, 2, \ldots, i-1, i+1, \ldots, N \tag{4}$$

where $da_j/da_i \neq 0$.

Hence, the production function can be expressed as:

$$y = F(\phi_1(a_i), \phi_2(a_i), \ldots, \phi_{i-1}(a_i), a_i, \phi_{i+1}(a_i), \ldots, \phi_N(a_i)) \tag{5}$$

Notice that the only team member who faces a problem of choice is the leader, since followers' choices depend deterministically upon the leader's decision.

The problem faced by leader is:

$$\max_{a_i} U_i = S_i(y) - V_i(a_i)$$

s.t.: $U_i = S_i(y) - V_i(a_i) \geq 0$

$$\sum\nolimits_{j=1}^{N} S_j(y) \leq y$$

$$S_j(y) - V_j\big(a_j\big) \geq 0$$

$$y = F(\phi_1(a_i), \phi_2(a_i), \ldots, \phi_{i-1}(a_i), \phi_{i+1}(a_i), \ldots, \phi_N(a_i))$$

$$a_j \geq 0 \ for \ j = 1, 2, \ldots, N$$

The first-order condition for the above problem is:

$$\frac{dS_i}{dy}\left[\frac{\partial F}{\partial a_i}+\sum_{j=1,j\neq i}^{N}\frac{\partial F}{\partial a_j}\frac{d\phi_j}{da_i}\right]=\frac{\partial V_i}{\partial a_i} \tag{6}$$

This solution to the team problem with leadership will be efficient if the following conditions hold:

$$\frac{\partial F}{\partial a_i}=\frac{dV_i}{da_i}=\frac{\sum_{j=1,j\neq i}^{N}\frac{dV_i}{da_j}\frac{d\phi_j}{da_i}}{1-\left(dS_i/dy\right)}=\frac{\sum_{j=1,j\neq i}^{N}\frac{dV_i}{da_j}\frac{d\phi_j}{da_i}}{\sum_{j=1,j\neq i}^{N}\frac{dS_j}{dy}} \tag{7}$$

Therefore, the optimality of the solution of the leader choice will depend upon the ratio defined as the sum of the marginal costs (dV_i/dy) multiplied by the derivatives of the reaction functions $(d\phi_{ij}/da_i)$ divided by the sum of the derivatives of the compensation functions of (dS_j/dy) of the followers. Condition 7 is trivially met under the following assumptions: (1) reaction functions are defined so that each follower equals the leader's contribution, i.e. $a_i = a_j$ for $j = 1,2,\ldots,N$; (2) the output share is egalitarian, i.e. $S_i = S_j = 1/N$; and (3) marginal costs are also equal between team members, namely, $dV_i/dy = dV_j/dy$ for $i,j = 1,2,\ldots,N$. These outcomes of the theoretical model are the basis for designing the experiments described further.

4 Experimental Design

4.1 Minimum Effort Game

The MECG has been useful to examine groups' ability to coordinate (Myung, 2009) in many economic (Bryant, 1983) and management (Fatas et al., 2006) phenomena. Previous studies on the MECG have focused on different issues such as communication and signals within the group (R. Cooper et al., 1992); entry fees to join the group (Cachon & Camerer, 1996); multiple groups competing with each other (Myung, 2009); group size (R. W. Cooper et al., 1990; Knez & Camerer, 1994; Van Huyck et al., 1990; R. A. Weber, 2006), sequential instead of simultaneous decisions (C. F. Camerer et al., 2004), or pre-game communication (R. Cooper et al., 1992; Riechmann & Weimann, 2008).

The paper proposes a MECG framework to investigate the effect of endogenous/exogenous leadership on team members' behavior. Real problems in companies and industries have been associated with coordination (Fatas et al., 2006). Moreover, there are previous studies in team production with strong complementarities that apply the MECG (Van Huyck et al., 1990). This research proposes teams of three members who privately exert an effort level or contribution. In the first treatment (control), the game is simultaneous, and the second and third treatments (with leadership effect) involve two consecutive decisions: first, the leader chooses its contribution to the team and sends a 'suggestion' on the contribution that each follower should make. The leader's contribution is private information; thus, followers are unaware of the leader's choice, and they

simultaneously decide their contribution after receiving the leader's suggestion. Contributions are defined as any natural number between zero and fifty (namely, $C_i \in (0, 50)$, $i \in \{1, 2, 3\}$) that team members wish to devote to the collective task. The output of this task is represented by a Leontief production technology, considering that the inputs are pure complements. Hence, the output is determined by the minimum contribution of the three participants, and any deviation from such a minimum is a loss.

The experiment adopts a 'within' treatment approach, as the same subjects and teams performed the same two consecutive treatments. The payoff function (π_{it}) is the same for three treatments and is computed as the double of the minimum contribution (C_{1t}, C_{2t}, C_{3t}) minus the contribution of subject i in period t (C_{it}).

$$\pi_{it} = 2min\{C_{1t}, C_{2t}, C_{3t}\} - C_{1t} \tag{8}$$

Given that, for the "control treatment", the game is played simultaneously, the dilemma of player i is to predict and choose the minimum effort of the team, taking into account that any positive deviation from this value implies a net utility loss.

For the endogenous and exogenous treatments, the game is sequential; the leader contributes first, and then her two followers simultaneously decide their contribution. Followers made their choice after receiving the leader's suggestion but with no information on the effectiveness of the leader. In this case, leaders are expected to convince followers that only the maximum contribution is optimal. Nevertheless, any situation in which $C_1 = C_2 = C_3$ is a Nash equilibrium in pure strategies for both treatments. Given that C_1 is an integer bounded at 50 as a maximum, it becomes clear that $C_1 = C_2 = C_3 = 50$ is the unique efficient (Pareto-optimal) equilibrium. The key difference between treatments is rooted in the kind of leadership and whether the game is simultaneous or sequential. The rationale of the sequential game with leadership implies that the leader will use her suggestions to the followers to achieve coordination at a more efficient equilibrium. Since communication between the leader and the followers is feasible, the suggestion made by the leader can be an effective way to improve coordination and, thus, efficiency (Brandts & Cooper, 2007; Sahin, Eckel, & Komai, 2015; R. Weber, Camerer, Rottenstreich, & Knez, 2001). If followers trust the leader, they should infer that the (unknown) contribution of the leader equals her suggested contribution. The theoretical predictions of the model in Sect. 3 and the above arguments lead us to formulate the following proposition:

P1: Leadership induces more efficient contributions/outcomes in teamwork.

Conversely, if followers do not trust their leader, they can adopt two behaviors: (a) choosing their contributions as if there were no leader, i.e. their choices will be solely based on the experience from previous decisions; or (b) selecting a lower contribution than that suggested by the leader on the belief that the leader is trying to deceive them. Both behaviors of followers would lead to rejecting P1, but they differ in terms of efficiency levels. When followers behave as if the leader is 'useless' (case a), the efficiency of the outcome will be similar to the treatment with no leadership, but if the followers believe that their leader is a 'deceiver' (case b), efficiency can be even lower than teams with no leadership.

There are also differences between teams depending on the selection process of the leader. A team member should bid higher than their mates when she is more confident

in her ability to achieve better coordination of the team and, thus, maximize her profits by leading followers to contribute the maximum. Moreover, the leader, as the auction winner, must incur an upfront cost, an investment only recoverable if the team's output is high. These arguments support the following proposition:

P2: Endogenous leadership implies more efficient equilibria than exogenous leadership.

4.2 Procedures

The experiment was programmed in the Z-tree toolbox (Fischbacher, 2007) and conducted in the computer room of the Faculty of Economics and Management at the University of Salamanca. At the beginning of every session of the experiment, three-player teams were randomly chosen. These teams remained unaltered during the experiment, and their members were also kept anonymous during and after the experiment. The experiment consisted of three treatments: the "control treatment" (Control) that was performed considering that there was no leader, and thus, the decisions of the three subjects were simultaneous; the "exogenous leadership" treatment, in which the leader is selected randomly; and the "endogenous leadership" treatment, in which subjects had an initial endowment of $1000 to bid in an auction for the position of the leader. Thus, the member with the highest bid on every team was selected as the leader. In both exogenous and endogenous treatments, once the leader had been chosen, she or he remained unchanged during all the treatment decisions. There were programmed five sessions (groups), where only two of the three treatments were applied in every session. Thus, it is considered a 'within group' approach. The treatment order changed in the different sessions to control for possible 'order effects'.

Experimental subjects consisted of 138 students enrolled in two undergraduate programs of the aforementioned University ('Economics' and 'Business Administration'). Subjects were considered unexperienced as they had never participated in a similar activity before, and they were incentivized according to their performance during the experiment and in terms of their payoffs.

All sessions were organized according to the availability of the schedules of the participants and limited to a maximum of 33 participants per group. Information exchange between team members was not allowed during the treatment without a leader. In both treatments with leadership, the leader must send a suggested contribution for the next decision in every round to the remaining members of the team. The message was '*I suggest you to make a contribution of x in your next decision*', where x was an integer between 0 and 50. Once all subjects made their decisions, they were privately informed of their own payoffs, but not about the payoffs or decisions of their partners, although from the payoff function (Eq. 8), they might infer some kind of information related to them (i.e., the minimum contribution).

4.3 Hypotheses

The MECG has multiple and symmetrical Nash-equilibria: any profile with identical contributions from members within a team. Nevertheless, there exists a unique Pareto-optimal equilibrium that corresponds to the maximum contribution for any teammate

(C_1=C_2=C_3=50). Unlike this theoretical prediction, previous experimental studies have found that subjects might converge to the low-effort equilibrium (Devetag & Ortmann, 2007).

Consistent with our proposition P1, leadership (either endogenous or exogenous) can be a solution to overcome such inefficiency in teamwork. This proposition is also supported by studies that find that the presence of a leader in a team improves the overall outcome (Van der Heijden & Moxnes, 2003). Leaders influence and motivate teams; they do not coerce, as they achieve results by developing a shared vision and communicating it to the team (Sohmen, 2013). However, early findings show that behavior can differ depending on whether a role is earned or randomly assigned (Hoffman, McCabe, Shachat, & Smith, 1994; Hoffman & Spitzer, 1985). Randomly selected leaders failed in their aim to improve coordination in teams (R. Weber et al., 2001), mainly when team members felt the leader's suggestion as an upper bound on their own decisions (Levy, Padgitt, Peart, Houser, & Xiao, 2011).

It is well known, that there is no evidence about the role that the selection procedure of the leader plays in the outcome of the team. The proposal is justified as an attempt to approximate the process of leader selection without compromising the anonymity of the team members. The logic of the 'leader by auction' is applicable to democratically elected leaders since they should incur upfront commitments and/or costs to earn this position. In this framework, teams with an elected leader tend to coordinate at higher effort levels (Reuben & Timko, 2017), since the elected leader has more influence or legitimacy over followers because of the way in which the leader is selected (Brandts et al. 2015). Also, effective team performance derives from characteristics like the need to integrate individual actions, perform in complex and dynamic environments, and finally, the need for team leadership (Zaccaro et al., 2001).

Therefore, the main hypothesis of this work, which conjectures that leadership increases cooperation in teamwork, can be subdivided in two, depending on the type of leadership:

H1: *Members of teams with exogenous (H1a) or endogenous (H1b) leadership contribute more that members of teams without a leader.*

5 Results and Discussion

The results are described in terms of three comparisons. The first compares both endogenous and exogenous leadership against the control treatment, and the second studies team performance based on exogenous versus endogenous leadership. In both cases, the main descriptive statistics analyze the effort levels of the different groups and the treatments. Then, the hypotheses H1 and H2 were tested with non-parametric statistics (Wilcoxon test). In the third section, the panel presents data models to analyze the dynamics of the contributions and test the three main hypotheses of our research using a parametric approach.

5.1 Leadership Treatments Versus Control Treatment

5.1.1 Control Treatment Versus Exogenous Treatment

In the first stage, groups 1 and 2 are compared. These groups correspond to control and exogenous treatment, albeit in a different order.

Descriptive Statistics

The main descriptive statistics of the contributions of individuals for Control and Exogenous treatment are displayed in Table 1 with Panels A (Group 1) and B (Group 2). Both panels only differ in the order in which both treatments were run. Additional data like measures of central tendency (mean, median, and mode) and dispersion (standard deviation) are shown, as well as the maximum and minimum values in the first and last rounds of the corresponding experiment.

Table 1. Descriptive Statistics for Control and Exogenous treatments

	DESCRIPTIVE STATISTICS					Initial Contribution	Final Contribution
Treatment	N	Mean	Median	Standard Deviation	Mode	Max/Min	Max/Min
Panel A: Group 1							
Control	27	7.01	1	13.24	0	50/0	50/0
Exogenous	27	4.84	0	12.17	0	50/0	50/0
Panel B: Group 2							
Exogenous	33	7.29	0	13.30	0	50/0	40/0
Control	33	4.65	0	11.53	0	50/0	50/0

The table reports main descriptive statistics for every group session and the maximum and minimum contribution at the beginning and end of the experiment.

As shown in Table 1, the mean and standard deviation of subjects' contributions are higher for the treatment administered in the first place. Actually, subjects of Group 1 contribute more, on average, to the Control than to the Exogenous treatment, whereas in Group 2, these results are reversed, namely, the Exogenous treatment offers a higher average contribution than the Control treatment. Similar results were obtained when comparing standard deviations. There are no differences in the ranges of initial and final contributions except when the exogenous treatment is performed in the first place (Group 2), where the maximum contribution is not achieved. These results support a clear 'order effect' since subjects seem to contribute more on average and with a higher deviation in the first treatment regardless of the existence of the exogenous leader. In addition, there is a decreasing pattern in contributions, particularly in the Exogenous treatment. This fact suggests that learning effects play an important role when the leader is randomly chosen, and thus, exogenous leadership is not effective in increasing contributions over time. In Sect. 5.3. This argument is better explained.

Figure 1 depicts the mean and standard deviation (S.D.) for the Control and Exogenous treatments in both groups by round. In Group 1, Exogenous treatment starts with higher values but tends to have lower contributions than Control treatment in subsequent rounds. Group 2 shows a more smoothly decreasing trend, but contributions from exogenous leadership remain higher than those of the Control with the exception of the first and last rounds. In both groups, standard deviation fluctuates without a clear trend.

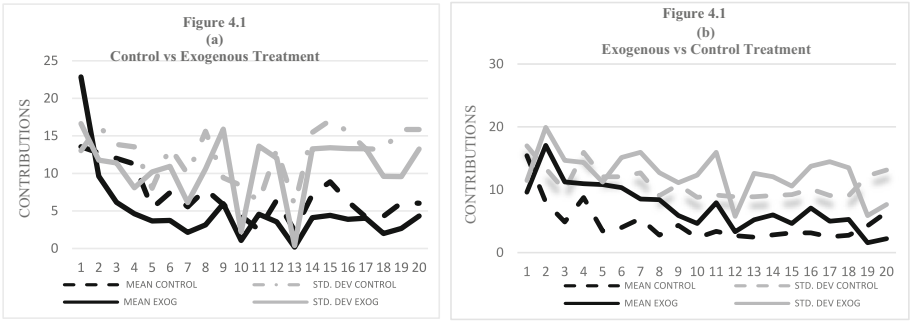


Fig. 1. Mean and standard deviation of the contributions over time

This figure shows the evolution of the mean contribution and its standard deviation (S.D.) for Group 1 and 2 in both the Control and Exogenous treatment.

5.1.2 Nonparametric Analysis

Given the 'within-subjects' nature of our experimental design, the Wilcoxon signed-rank statistic (Table 2) is used to confirm that the difference in average contributions between the exogenous and control treatments is ambiguous and fully determined by the order of the treatment. However, when the game starts with exogenous leadership, teams achieve a better average performance. Hence, non-parametric analysis partially supports our hypothesis H1a, since teams with an exogenous leader contribute more than those without a leader, but it cannot be discarded that these results are influenced by a learning effect.

Table 2. Wilcoxon Test for mean contributions in the different groups

	GROUP 1		GROUP 2	
Mean Contribution	Control	Exogenous	Exogenous	Control
	7,02	4,83	7,28	4,65
Z*	−5,28		5,51	
p-value	,000		,000	

*The test evidenced a clear order effect and then differences are due to learning more than treatment effects

5.2 Control Treatment Versus Endogenous Treatment

5.2.1 Descriptive Statistics

Measures of central tendency (mean, median, and mode) and dispersion (standard deviation) from endogenous and control treatments are shown in Table 3. As in the previous comparison, Panels A (Group 3) and B (Group 4) show the pooled values of the contributions of subjects for both treatments and each group session in the experiment.

Table 3. Descriptive Statistics for Control and Endogenous treatments

	DESCRIPTIVE STATISTICS					Initial Contribution	Final Contribution
Treatment	N	Mean	Median	Standard Deviation	Mode	Max/Min	Max/Min
Panel A: Group 1							
Control	27	7.01	1	13.24	0	50/0	50/0
Exogenous	27	4.84	0	12.17	0	50/0	50/0
Panel B: Group 2							
Exogenous	33	7.29	0	13.30	0	50/0	40/0
Control	33	4.65	0	11.53	0	50/0	50/0

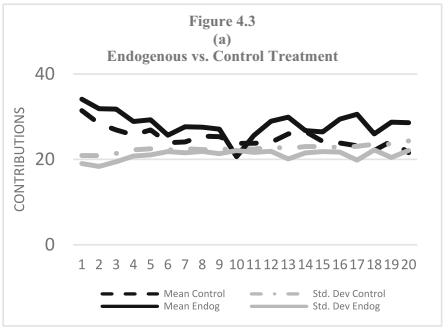
The table reports main descriptive statistics for every group session and the maximum and minimum contribution at the beginning and end of the experiment.

Central tendency measures (mean, median, and mode) in all groups are higher in the Endogenous than in the Control treatment. The standard deviation in both groups also exhibits a higher dispersion in the Endogenous treatment compared to the Control. Maxima, minima, and ranges of initial and final contributions are equal for all treatments/orders, and they exhibit an extreme dispersion of contributions. The most frequent value of contribution when the control treatment was performed first was the minimum (zero) while for the remaining treatments and orders, the mode was the maximum (50).

Figure 3 shows the mean and standard deviation (S.D.) for the Control and Endogenous treatments by round. Mean in both groups is higher in the Endogenous treatment regardless the treatment order. In Group 4 standard deviation is higher and exhibits a positive trend (Fig. 2).

This figure shows the evolution of the mean contribution and its standard deviation (S.D.) for Group 3 and 4 in both the Control and Endogenous treatment.

Nonparametric Analysis The hypothesis H1b was tested (i.e. the existence of significant differences in the median contribution between the two treatments) through the Wilcoxon signed-rank statistic. In this case, the test confirms that, regardless of the treatment order, teams contribute significantly more to the Endogenous than to the Control treatment (Table 4).



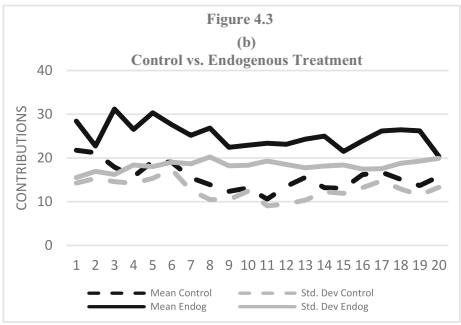


Fig. 2. Mean and standard deviation of the contributions over time

Table 4. Wilcoxon Test for mean contributions in the different groups

	GROUP 3		GROUP 4	
Mean Contribution	Endogenous	Control	Control	Endogenous
	28,26	25,06	15,65	25,23
Z*	−7.42		10.30[b]	
p-value	.000		.000	

*Endogenous treatment presents significantly higher contributions regardless the treatment order.
[b]The ranks of the test are based on the difference between the second and first treatment.

5.3 Exogenous Versus Endogenous Leadership

5.3.1 Descriptive Statistic

Table 5 displays the main descriptive statistics of the contributions of individuals to Exogenous and Endogenous treatment in Group 5. Note that in this case, possible order effects were not controlled for in this comparison.

Table 5. Descriptive Statistics for Control and Endogenous treatments

	DESCRIPTIVE STATISTICS					Initial Contribution	Final Contribution
Groups	N	Mean	Median	Standard Deviation	Mode	Max/Min	Max/Min
Panel A: Exogenous treatments							
Group 5	18	21.76	20	18.93	0	50.0	50.0
Panel B: Endogenous treatments							
Group 5	18	21.16	15	20.29	50.0	50.0	50.0

The table reports main descriptive statistics for group session and the maximum and minimum contribution at the beginning and end of the experiment.

Table 5 reveals that central tendency measures are slightly higher in the Exogenous than in the Endogenous treatment. However, the Endogenous treatment exhibits a higher dispersion (SD) compared to the Exogenous treatment. Maxima, minima, and ranges of initial and final contributions are equal or quite similar for all treatments/orders. Treatments also differ in their most frequent value (mode), supporting the fact that the contribution of subjects in the Endogenous treatment mostly selected the highest feasible contribution (i.e., 50), in contrast to subjects in the Exogenous treatment that mostly chose the lowest value (zero). Analyzing statistics by round (Fig. 5), the mean (standard deviation) turns out to be higher (lower) in almost all rounds.

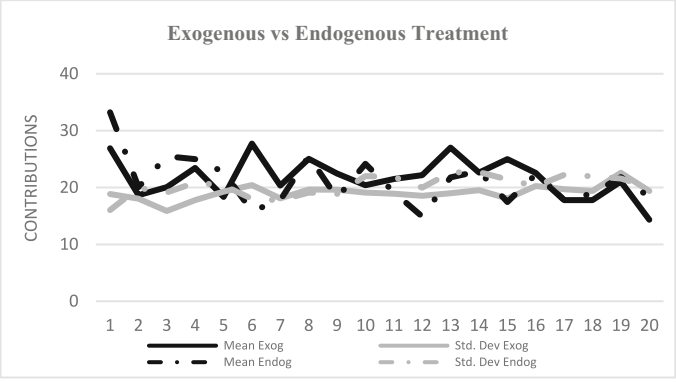


Fig. 3. Mean and deviation of the contributions over time

This figure shows the evolution of the mean contribution and its standard deviation (S.D.) for Group 5 in both the Exogenous and Endogenous treatment.

Figure 6 exhibits the median, maximum (MAX) and minimum (MIN) values of contributions along the sequence of decisions for every group. In general, the Endogenous treatment reveals higher median contributions, albeit the trend is unclear. The minimal and maximum contributions achieve the most feasible values in all cases.

5.3.2 Nonparametric Analysis

The Hypothesis H2 was testes through the Wilcoxon statistic, i.e. our conjecture that Endogenous treatment leads to higher contributions than the Exogenous treatment. However, in Group 5, Wilcoxon test does not find significant differences in contributions in both treatments, as shown in Table 6.

5.4 Econometric Analysis

This section provides dynamic panel data models to test the impact of the different types of leadership on the contribution of any subject of a three-player team i, namely, subject 1 (C_{1it}). The different treatments are tested through a dummy variable (T_{it}), which takes a value of 1 in the main scenario and 0 in the control scenario (further

Table 6. Wilcoxon Test for mean contributions in the different groups

GROUP 5		
Mean Contribution	Exogenous	Endogenous
	21,75	21,16
Z*	−1.67	
p-value	.096	

* No difference between Exogenous and Endogenous treatment is found at 5% level.

details for every model are provided below). To control for possible learning effects (i.e., the effect of the past on future decisions), not only the dynamics of contributions are considered, but also the treatment variable is introduced in a multiplicative way with the lagged values of both the dependent variable and the minimum contribution within a team, i.e.,$\min\{C_{1it-1}, C_{2it-1}, C_{3it-1}\}$. These interaction terms are aimed at capturing the marginal effects of past information on the treatment scenario. Finally, control variables such as nationality and gender are considered and included in the vector $\boldsymbol{X_{it}}$. Consequently, it is proposed the following basic model for subject 1 contributions to team i in period t:

$$C_{1it} = \beta_0 + \beta_1 C_{1it-1} + \beta_2 T_{it} + \beta_3 T_{it} \times C_{1it-1} + \beta_4 \min\{C_{1it-1}, C_{2it-1}, C_{3it-1}\} + \beta_5 T_{it} \times \min\{C_{1it-1}, C_{2it-1}, C_{3it-1}\} + \alpha' \boldsymbol{X_{it}} + \eta_i + \varepsilon_{it}, \quad (9)$$

$$for\ i = 1, 2, \ldots, N\ and\ t = 1, 2, \ldots 40.$$

Where C_{1it-1} represents the subject's 1 contribution in period $t - 1$, $\min\{C_{1it-1}, C_{2it-1}, C_{3it-1}\}$ is the minimum contribution of the three members of team i in period $t - 1$, and T_{it} is the dummy variable treatment scoring zero in the control treatment and one in the main treatment. It is noteworthy that the main treatment involves the first (second) 20 observations for groups 2 and 3 (1, 4 and 5). $\boldsymbol{X_{it}}$ is a vector containing the remaining control variables used in the various regressions (such as gender and nationality), $\eta_i i$ s the variable capturing the individual effects, and ε_{it} the error term (both satisfying the standard assumptions in panel data models).

The model, given the dynamic of its nature, was estimated by Generalized Method of Moments (GMM). Lagged endogenous variables were used as valid instruments to control for endogeneity (Arellano & Bond, 1991). The validity of the instruments was checked by the Sargan and Hansen tests.

Table 7 presents the results of four alternative models for the individual contribution that have a similar structure according to Eq. 9. Model 1 compares Exogenous leadership with the Control (no leadership) (Groups 1 and 2), finding an overall significant and positive treatment effect. Furthermore, subjects seem to be willing to increase their contributions the higher their own past contributions and the minimum efforts (output level) of their teams.

C_{1it-1}. Represent the contributions of subjects in period $t - 1$; $\min_{123it-1}$ Represents the minimum contribution of team i in period $t - 1$; T_{it} is the dummy variable scoring one in the main treatment (Exogenous, Endogenous, Endogenous and Leadership in

Table 7. Econometric models for the contribution of subject 1 (C_{1it}).

	MODEL 1 Exogenous vs. Control		MODEL 2 Endogenous vs. Control		MODEL 3 Exogenous vs. Endogenous		MODEL 4 Leadership vs. Control	
	Coef	P- value	Coef	P-value	Coef	P- value	Coef	P- value
C_{1it-1}	.3826796	0.000	.1048034	0.000	−.1075223	0.228	.1875453	0.000
T_{it}	3.605729	0.002	5.695091	0.002	−2.996537	0.831	5.110931	0.000
$\mathbf{min}_{123\mathbf{it}-1}$	.3507348	0.000	.4345609	0.000	.5114427	0.000	.5591369	0.000
$T_{it} \times min_{123it-1}$	−.4427721	0.000					−.13184	0.000
$T_{it} \times C_{1it-1}$	−.0901307	0.000					−.0773627	0.000
Nationality	−1.189749	0.140	36.09222	0.000			.019297	0.000
Gender	.6207872	0.034	1.324668	0.072			4.180999	0.000
Intercept	1.254226	0.030	9.046641	0.000	16.09283	0.006	3.374966	0.000
AR1	−4.99	0.000	−4.61	0.000	−2.03	0.042	−7.01	0.000
AR2	1.93	0.054	1.28	0.201	0.44	0.662	2.42	0.015
Sgan	2223.84	0.000	2070.17	0.000	595.94	0.000	4893.55	0.000
Hansen	56.82	1.000	51.65	1.000	10.96	1.000	126.80	1.000
N	60		60		18		138	

Models 1, 2, 3 and 4, respectively) and zero in control treatments with 'no leadership' in all models but Model 3 (Exogenous leadership).Nationality is a dummy variable that takes 0 for Spanish subjects and 1 non-Spanish subjects. Finally, gender takes 0 for men and 1 for women. The Arellano-Bond for testing autocorrelation of order 1 and 2 are labelled as AR1 and AR2, respectively; 'Sargan' and 'Hansen' denote the tests for the validity of instruments and N is the number of observations.

6 Conclusions

An experimental approach and compare the contributions of teams without any kind of leadership (simultaneous decision) to those with either endogenous or exogenous leadership (i.e., a sequential framework where the leader decides her contribution first and sends a message about her recommended contribution to the followers). In endogenous leadership, the leader is chosen through an auction in which all members of any team submit a bid, and the one with the higher bid wins the right to be leader during the whole treatment. In exogenous leadership, the leader is randomly chosen for the whole treatment. A production technology is assumed in which the output depends directly on the minimum contribution within the three-player team, and only this information is revealed to the team members once they have made their decision for every period. A repeated game was implemented within subjects during 20 rounds per treatment with the same teams, and thus learning effects might play an important role in the decisions. On the other hand, it was controlled for possible order effects when testing the impact of treatment as well as possible interactions between input dynamics and treatment.

Leadership has a significant and positive impact on team production, but this effect is different when considering either an endogenous or exogenous selection of the leader.

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