Free-Riding and Knowledge Spillovers in Teams

The Role of Social Ties

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We investigate whether and how social ties affect performance in teams implementing a field experiment in which a sample of undergraduate students are randomly assigned to teams composed by friends and teams composed by individuals not linked by friendship relationships. Students undertake an intermediate exam divided in two parts: one graded on the basis of individual performance and the other graded on the basis of team performance. We find that students assigned to socially connected teams perform significantly better than control students in the team part and in the individual part of the exam, suggesting that social ties are relevant both for solving free-riding problems and for inducing positive knowledge spillovers among teammates. The positive effect of friendship in teams persists and treated students have a better performance also in the second test, when students are evaluated exclusively on the basis of their individual performance.

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1. Introduction

Teamwork is important in a wide range of fields, such as research, sport and business activities. In many jobs production is carried out by groups of individuals who work in close collaboration. According to Bikfalvi et al. (2014), in Europe six out of ten manufacturers with more than 20 employees have implemented teamwork in production. Teamwork is pervasive also in the US with about 52% of firms relying on this type of work incentives. Similarly, decision-making in organizations is increasingly performed by teams rather than by individuals (Woolley et al., 2010; Hamilton et al., 2003).

Contract theory has shown that the use of pay schemes based on aggregate measures of performance, such as team output, generates free-riding behaviors that involve efficiency losses due to workers exerting less effort with respect to individual incentives. Thus, a crucial feature of successful organizations is the ability to overcome free-riding by designing effective monitoring schemes (Alchian and Demsetz, 1972), by using budget-breaking devices aimed at threatening potential free riders (Holmström, 1982) or by establishing social norms that penalize opportunism (Corgnet et al., 2015; Kandler and Lazear, 1992). These norms can be created through investments in corporate culture aimed at instilling a sense of belonging to a group of employees and at enhancing their preferences for cooperation. Peer pressure coming from various channels (desire to be liked or respected by teammates; sense of responsibility; fear of social punishment or feelings of altruism, guilt or shame) can also play an important role. The social cost of deviating from the norms of cooperation enters the utility function of the individual, causing him\her to temper opportunistic behavior. This social cost of undertaking opportunistic behavior might depend on the composition of the group (Towry, 2003; Reagans and Zuckerman, 2001; Spagnolo, 1999) and social ties among team members might encourage cooperation in the workplace (Babcock and Hartman, 2011; Karlan, 2007; Balkundi and Harrison, 2006). Compared to strangers, friends may be better able to motivate and monitor each other. Also friends may be more likely to work together and interact to share information and knowledge. Thus, being in a socially connected team may have two positive effects: attenuation of free-riding and enhancement of knowledge spillovers.

At the empirical level, the evidence of free riding behavior in teams is limited (e.g. Encinosa, Gaynor and Rebitzer, 2007; Leibowitz and Tollison, 1980). Instead, both laboratory and field experiments find positive effects of team incentives (Dohmen and Falk, 2011; Dumaine, 1990, 1994; Hamilton, Nickerson and Owan, 2003; Hansen, 1997; Ichniowski et al., 1996; Ichniowski, Shaw and Prennushi, 1997; Kruse, 1992; Manz and Sims, 1993; van Dijk, Sonnemans and van Winden, 2001). For example, Hamilton, Nickerson and Owan (2003) show that equal sharing of production bonuses within teams seems to stimulate cooperation, information sharing, monitoring and even mutual training, generating a productivity increase (relative to individual incentives) despite the expected free-rider problem.

Since in real life situations individuals self-select in teams, it is difficult to disentangle the effect of social ties among team members on team performance. With the aim of providing evidence on the causal

relationship between social ties and team performance, we have conducted a field experiment in which individuals – who have stronger incentives to perform well and are observed in a real life environment –are randomly assigned to a teammate who is or not a friend.

Our experiment has involved students enrolled at an economic course in an Italian University. Students were offered the possibility to join the experiment consisting in the possibility to take an intermediate test based partially on team performance. Then, students were invited to answer an online survey asking them to name five friends among students attending the same course. Alternatively, students not joining the experiment could sit the final exam of the course according to the standard scheme.

A total of 260 students joined the experiment out of 274 students enrolled at the course. They were randomly assigned to a treatment group with teams composed by two friends and a control group with teams composed by two students that were not linked by friendship relationships. Importantly, the friendship relationship on which basis treated teams are formed represents pre-existing ties among teammates – and between students of different teams – not ties originating from team interactions. Since the course considered is taught during the third year of university, students have known each other for almost three years at the moment of the experiment.

The name of teammates and the parts of the program evaluated on the basis of individual and team performance, respectively, were communicated to students during the first week of teaching classes. In this way, teammates had time to work together and had all the necessary information to decide how to allocate their studying effort. The intermediate test, to sit right after the first half of the course, was composed by two parts: one evaluated on the basis of individual performance and the other based on team performance. A final test was scheduled at the end of the course and was totally based on individual performance.

Our experimental design allows us to investigate whether social ties help to reduce free-riding and create positive spillovers among teammates. If social ties are relevant exclusively to attenuate free-riding problems we should find a positive effect on students' performance in team and no effect on the individual part. Furthermore, if social ties also enhance positive knowledge spillovers, since friends are more likely to work together and to share their knowledge, the effect of positive spillovers should spread across the two components of the test because a better understanding of any part of the course program improves the understanding of the other parts. Then, students belonging to a socially connected team should perform better than students belonging to teams without social ties also in the part of the test evaluated on the basis of individual performance. In addition, if both the channels are relevant, the estimated effect of social ties on individual performance should be smaller than the effect produced on team performance.

We find a positive and statistically significant effect of being part of a socially connected team on team performance: treated students obtain a grade of about 1-1.1 points higher than the grade obtained by control students (which translates in an increase of about 18-20% in performance). We find a positive and statistically significant effect also when considering as dependent variable the score at the individual part (+0.7 points, about

11% of the mean). However, the effect is smaller compared to that one found when considering students' performance at the team part. This evidence suggests that social ties are relevant both for solving free-riding problems and for enhancing positive spillovers among teammates.

We also study team heterogeneity in terms of ability and find some (weak) evidence that individuals without social ties tend to provide less effort when their own level of ability is different from their mates' ability, while the effort of socially connected individuals does not depend on their mates' abilities.

Our paper is related to the literature investigating the role of friendship among teammates and the optimal composition of teams (although in our setting team composition is exogenous). Hamilton, Nickerson, and Owan (2003) show that individuals might prefer to form teams with friends to enjoy the nonpecuniary benefits of working with them, while Bandiera, Barankay, and Rasul (2005) emphasize the opportunity given by friendship of reducing free-riding and enhance cooperation. Babcock et al. (2012) show that team incentives can outperform individual incentives in fostering students' attendance at a study hall in the library when being assigned to a known partner. An anonymous partner produces virtually the same effect of individual incentives, suggesting that knowledge of the partner plays an important role. They also find smaller but similar effect in gym attendance. On the other hand, Bandiera, Barankay, and Rasul (2013) shows that when incentives are stronger, because of team rankings or team tournaments, individuals are more likely to form teams with people with the same level of ability instead of choosing friends.

The paper is organized as follows. In Section 2 we describe our experimental design and present the data. In Section 3 we carry out our main empirical analysis that investigate students' performance in the team part of the test. In Section 4 analyzes students' performance in the individual part of the test and in the final test. Section 5 studies the effects of the heterogeneity of abilities within each team. Section 6 concludes.

2. Experimental Design and Data

2.1. Experimental Design

To investigate the effects of social ties on team performance, we ran a field experiment involving students enrolled in the academic year 2014-2015 at the course of Personnel Economics, offered by the First Level Degree Course in Business and Administration at the University of Calabria.[1]The course was taught to students during the second semester (teaching period from February to May).

[1] The University of Calabria is a middle-sized public university located in the South of Italy. It has currently about 35,000 students enrolled in different Degree Courses and at different levels of the Italian University system. Since the 2001 reform, the Italian University system is organized around three main levels: First Level Degrees (3 years of legal duration), Second Level Degrees (2 years more) and Ph.D. Degrees. In order to gain a First Level Degree students have to acquire a total of 180 credits. Students who have acquired a First Level Degree can undertake a Second Level Degree (acquiring 120 more credits). After having accomplished their Second Level Degree, students can enroll in a Ph.D. degree.

In the first lecture of the course, in alternative to the standard exam – consisting of a single test on the whole program to be taken at the end of the course and evaluated on the basis of student's individual performance – all the enrolled students (274) were given the possibility to join an experiment introducing work in team and an alternative evaluation scheme.

The experiment introduced an intermediate test on the first part of the course program (about 3 chapters of the textbook), to be completed with a final test on the second part of the program. The intermediate test was composed by two parts, one evaluated on the basis of individual performance ("the individual part") and the other evaluated on the basis of team performance ("the team part"). The individual part counted for 2/3 of the total marks (students could gain a maximum of 20 points), while the remaining 1/3 of the marks depended on team performance (students could gain a maximum of 10 points).

Students were assigned to teams of 2 members and each student's mark was the average of the points obtained by her/his team. The total score of the intermediate test was given by the sum of the marks obtained at the individual part and at the team part (average grade between student *i* and *j* in the team):

$$Grade\ Intermediate\ Test_i = IndividualeGrade_i + \frac{TeamGrade_i + TeamGrade_j}{2}$$

The final test was on the second part of the course program and the evaluation was based only on individual performance with scores ranging from 0 to 30. The final exam grade was given by the average of the grades obtained in the intermediate and the final test.[2]

Students were given 5 days to choose whether to sit the exam under the standard exam or joining the experiment. However, as required by the university administration for ethical reasons, they were made aware that even if joining the experiment, they were free to leave it at any time (also after having taken the intermediate test) and to sit the standard exam, which was scheduled the same day as the final test.

We asked students to join the experiment by answering to an on-line survey asking some questions on their social networks, some psychological attitudes and their family background. In particular, we asked each student to name a maximum of five friends among students attending the course. Since the course considered is taught during the third year of university enrolment, students have known each other for almost three years at the moment of the experiment.

A total of 260 students joined the experiment and only 14 students among those enrolled to the course did not join.

Using the names of friends provided by each student we created a list of potential couples with mutual correspondence, that is, we considered only couples when student *i* named student *j* as a friend and, at the same time, the latter named the former as a friend.

We formed 678 mutual couples and assigned a random number *u* to each couple. Then we sorted couples on the basis of *u* and assigned the treatment to the students in the first 65 couples, that is 130 students (skipping

[2]In a standard exam, grades range from 0 to 30. Only students reaching a final grade of at least 18 pass the exam.

couples when one of the student was already assigned previously). The remaining 130 students represent the control group: they were assigned randomly to 65 teams of two students on the basis of their *High School Grade*.

As measures of social interactions, which could be correlated to some kind of abilities, for each student we calculated the number of friends named in our Survey (*# Friends*), the number of times other students named him/her (*#Received Nominations*) and the number of mutual couples formed (*# Mutual Couples*).

Since some parts of the course program might be more difficult than others, we divided the program in three sections (A, B, C) and randomly assigned section A to the individual part and section B to the team part for 50% of the teams, and assigned section B to the individual part and section A to the team part for the remaining 50%. Section C was assigned always to the individual part.

Students were promptly informed of the team composition and the parts of the course program assigned to teamwork and to individual work.[3] Both treated and controls students attended the lectures in the same room, at the same time and with the same instructor and teaching material. After four weeks of teaching classes students undertook the intermediate test. All students took the test with the same questions and at the same time. Tests were marked and students were informed about the mark obtained: teaching assistants marking the tests had no information on whether students were assigned to the treatment or the control group.

At the end of the course, students completed the exam undertaking the second part of the test or, alternatively, took the standard exam. In both these tests, students were evaluated exclusively on the basis of their individual performance.

2.2. Data, Descriptive Statistics and Balance Checks

We started with a sample of 260 students joining the experiment: 130 of them were "treated" and assigned to "socially connected teams" and the remaining 130 were in the control group and assigned to "no socially connected teams". The dummy variable "Socially Connected Team" identifies treatment.

Descriptive statistics are reported in Table 1. About 56% of students joining the experiment are females. Students are on average about 22 years old. *High School Grade* (ranging from 60 to 100) is on average about 85. 58% of students joining the experiment have studied in a Lyceum. On average, students expect to obtain a grade of 25.5 at the exam. Average parents' years of education is 11.7. 83% and 48% of respectively fathers and mothers are employed. Almost 50% of students come from the same province of the University. The average number of friends named by students was 4.68 (the vast majority named the maximum of 5), students received on average 4.02 nominations, and each of them was part of 2.67 mutual couples. As regards the gender composition of the teams, 41% were composed by two females, 29% by two males and the remaining were

[3] We informed students that if one of the students did not show up at the intermediate exam, in order to compute the score obtained in the team part of the test by his/her teammate we would replace the absent student with a randomly selected student with the same expected ability of the present mate.

mixed couples.

Students were allowed to change their mind and switch back to the standard exam. Thus, even if almost all students (95%) signed up to join the experiment, 52 (20%) did not show up at the intermediate test. Thus, 208 students took part to the intermediate test: 105 in the "socially connected team" group and 103 in the "no socially connected team" group.

The grade obtained at the team part was on average 5.67 (ranging from 0 to 10) while the grade obtained at the individual part was 6.17 (we rescaled the grade at the individual part by dividing by two to make it comparable with the grade of the team part).

Table 1. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Obs
Socially Connected Team	0.500	0.501	0	1	260
Female	0.562	0.497	0	1	260
Age	21.891	0.583	20.408	23.923	260
High School Grade	85.496	9.159	66	100	260
Lyceum	0.581	0.494	0	1	260
Expected Grade	25.546	2.253	18	31	260
Section A in Team	0.515	0.501	0	1	260
Parents' Education	11.683	3.188	2.5	18	260
Father: Employed	0.835	0.372	0	1	260
Mother: Employed	0.477	0.500	0	1	260
Same Area	0.496	0.501	0	1	260
# Friends	4.681	0.715	2	5	260
# Received Nominations	4.019	2.391	1	15	260
# Mutual Couples	2.669	1.303	1	5	260
Present	0.800	0.401	0	1	260
Female-Female	0.415	0.494	0	1	260
Female-Male	0.146	0.354	0	1	260
Male-Female	0.146	0.354	0	1	260
Male-Male	0.292	0.456	0	1	260
Grade Team Part	5.668	3.001	0	10	208
Grade Individual Part	6.171	2.807	0	10	208

Notes: Sample of students joining the experiment.

In Table 2 we report mean values separately by treatment groups, both for the sample of students joining the experiment (columns 1 and 2) and for those actually showing up at the intermediate test (columns 5 and 6) to verify that students are successfully randomized both ex-ante and ex-post. Indeed, since we could not force students joining the experiment to effectively show up at the intermediate test, it could be that they self-selected in relation to their assigned teammate.

Differences in means between treatment and control are presented in column 3 (Standard Errors in column 4) for the sample of students joining the experiment and in column 7 (Standard Errors in column 8) for the sample of students effectively taking the exam. Results show that the randomization was successful in creating comparable treatment and control groups with regard to the observable characteristics: there are no significant differences between the treatment statuses in terms of students' gender, age, high school grade, type

of high school attended both when we consider the sample of students joining the experiment and when looking at the subsample of students actually showing up at the intermediate test. Only the difference in the number of friends (about 0.2) turn out to be statistically significant between treated and control groups, while the differences in the number of received nominations and in the number of mutual couples formed are not different from zero.

However, since students tend to name friends of their same gender, the percentage of teams with two males or two females is significantly higher in the group of "socially connected teams" than in the "no socially connected teams" group. The opposite is true for mixed gender teams., Treated couples tend to be prevailingly single-sex: 46% of treated couples are females (compared to 37% in the control group) and 38% are males (compared to 20% in the control group). To avoid any possible bias, we take this aspect into consideration by controlling for the gender composition of the couples in our estimates.

Table 2. Balance Checks. Student Characteristics across Treatment and Control Groups

	Panel (a). Joining the experiment				Panel (b). Taking the exam			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Treated	Control	Diff. T-C	S.E.	Treated	Control	Diff. T-C	S.E.
Female	0.538	0.585	-0.047	(0.062)	0.486	0.573	-0.087	(0.083)
Age	21.859	21.923	-0.064	(0.072)	21.884	21.896	-0.012	(0.084)
High School Grade	84.662	86.331	-1.669	(1.134)	84.943	86.893	-1.95	(1.475)
Lyceum	0.562	0.600	-0.038	(0.061)	0.590	0.641	-0.05	(0.076)
Expected Grade	25.569	25.523	0.046	(0.280)	25.895	25.786	0.109	(0.325)
Section A in Team	0.492	0.538	-0.046	(0.088)	0.524	0.563	-0.039	(0.095)
Parents' Education	11.692	11.673	0.019	(0.396)	11.490	11.777	-0.286	(0.466)
Father: Employed	0.823	0.846	-0.023	(0.046)	0.829	0.835	-0.006	(0.051)
Mother: Employed	0.500	0.454	0.046	(0.060)	0.476	0.437	0.039	(0.069)
Same Area	0.477	0.515	-0.038	(0.062)	0.457	0.495	-0.038	(0.082)
# Friends	4.777	4.585	0.192	(0.091)	4.800	4.573	0.227	(0.102)
# Received Nominations	3.885	4.154	-0.269	(0.297)	4.162	4.515	-0.353	(0.354)
# Mutual Couples	2.623	2.715	-0.092	(0.162)	2.743	2.854	-0.112	(0.184)
Present	0.808	0.792	-0.047	(0.062)				
Female-Female	0.462	0.369	0.093	(0.061)	0.419	0.359	0.060	(0.093)
Female-Male	0.077	0.215	-0.138	(0.043)	0.067	0.214	-0.147	(0.044)
Male-Female	0.077	0.215	-0.138	(0.043)	0.076	0.204	-0.128	(0.044)
Male-Male	0.385	0.200	0.185	(0.055)	0.438	0.223	0.215	(0.088)
Obs.	130	130			105	103		

Notes: Panel (a): students joining the experiment; Panel (b): students effectively taking the exam.

In the Appendix (Table A1), we show that the decision to take the intermediate test is not affected by the assigned treatment group although it is affected by individual characteristics (females and lower ability students are more likely to not show up).

3. Do social connections help to overcome free-riding? Students' performance at teamwork

The literature on teamwork and incentives shows that evaluating individuals on the basis of team performance leads to free-riding, namely members of the team do not contribute or contribute less to team output and enjoy their share of teammates' performance. As shown in Appendix (Table A2) we also find that students perform significantly worse when engaged in team work with respect to individual work. However, social ties may contribute to the attenuation of free-riding issues because friends may be better able than strangers to motivate and monitor each other and increase the social cost of deviating from cooperation.

Teamwork has also positive spillovers if teammates help each other and each teammate shares his/her knowledge with the group. Social ties may enhance positive spillovers if friends are more likely than no-socially connected individuals to work together in a cooperative environment and to share their knowledge.

If social ties are indeed beneficial to reduce free-riding and to generate positive spillovers, then, in our setting, the performance of treated students (linked by mutual friendship) in the team part should be better than the performance of control students.

To provide evidence on these effects we estimate the following linear regression model:

$$Grade\,Team\,Part_i = \beta_0 + \beta_1 Socially\,Connected\,Team_i + \beta_2 X_i + \beta_3 G_i + \beta_4 S_i + \varepsilon_i$$

where *Grade Team Part*$_i$ is the dependent variable of the model, that is, the grade that student *i* scores at the part of the test assigned for teamwork; *Socially Connected Team*$_i$ is a dummy variable taking the value of 1 when student *i* is assigned to a team with one of his/her friends and 0 otherwise; X_i denotes the vector of student's predetermined characteristics and cognitive ability (*Female*, *Age*, *High School Grade*, *Expected Grade*, etc.), a dummy variable for those students who are matched with a student who did not show up at the test (*Absent Mate*) and a dummy for the section of the course program evaluated on the basis of team performance (*Section A in Team*), family background and so on; G_i includes a vector of dummies to capture the gender composition of team pairs (*Female-Female*; *Female-Male*; *Male-Female* while male students coupled with a male mate are left as reference category); S_i includes three measures of social interactions of the student (number of friends, received nominations and mutual couples formed); ε_i is an error term.

Table 3 reports OLS estimates for the impact of being part of a socially connected team on students' team performance. Our sample is represented by 208 students showing up at the intermediate test. In all the tables, Standard Errors are corrected for heteroskedasticity and allowed for clustering at the team level.

In the first specification we only consider as a regressor the dummy variable *Socially Connected Team* and we find a positive and almost statistically significant relationship (*p*-value=0.11) between being part of a

socially connected team and student's performance at the team part: treated students obtain a +0.737 higher grade than control students assigned to teams with no social connections.

The second specification adds among controls *Female*, *Age* and *Section A*. The effect of *Socially Connected Team* is similar in magnitude (+0.787) and significant at the 10 percent level while the additional controls are not significant. In column 3 we add some controls for students' abilities: *High School Grade*, *Expected Grade* and *Lyceum*. These variables are all positive and very significant: the R-squared jumps from 0.02 to 0.23. The causal effect of social ties is in this specification +1.05 and is significant at the 1 percent level.

In column 4 we control also for parents' education and employment status, for the residence of students and for the dummy *Absent Mate*:[4] the effect of treatment is very similar (+1.10). In column 5 we include the three dummies for the gender composition of the team (excluding *Female* from our controls): while the gender composition of the team does not seem to affect performance (the F-test for the joint significance of these variables is 0.7 with a *p*-value of 0.55) the impact of being part of a socially connected team is still positive and statistically significant at the 1 percent level and larger in magnitude (+1.22) compared to the specification with fewer controls.

To investigate whether having a mate who decided to not show up produces different effects for control and treated students, in column 6 we include among controls an interaction term *Socially Connected Team*Absent Mate*. Interestingly, we find that socially connected teams have a larger effect (+1.40) when a student's mate is effectively present at the exam. On the other hand, the interaction term attracts a negative and statistically significant coefficient (–1.74): this implies that the positive effect of social connections completely vanishes (–0.34, t-stat=–035) for students whose mates do not show up at the exam (while an absent mate does not produce any statistically significant effect on control students). This finding further confirms that socially connected teams generate a positive effect that cannot be realized when one of the student does not take part to the exam (and probably does not undertake studying activity ex-ante).

All in all, we find a strong effect of *Socially Connected Team*: considering that the average grade in team is 5.67, social connections increase performance of about 19% or 0.36 Standard Deviation of the dependent variable (considering column 4 of Table 3).

We have also performed separate regressions for males and females: although females seem to benefit slightly more from social connections (1.31 vs. 1.15) we do not find significant gender differences in response to treatment (results not reported).

We have also tested the role played by a number of non-cognitive abilities, such as risk and intertemporal preferences and an indicator of procrastination, which we measure using students' answers to specific questions included in the on-line survey and aimed at capturing these psychological traits. These controls are far from being statistically significant and do not affect our main results (estimates not reported).

[4]In our sample there are 28 students who were coupled with a student who did not show up at the test.

Table 3. Social Connections and Team Performance: OLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Socially Connected Team	0.737	0.787*	1.052***	1.102***	1.221***	1.400***
	(0.461)	(0.458)	(0.382)	(0.378)	(0.425)	(0.444)
Female		0.734	0.149	0.063		
		(0.454)	(0.406)	(0.395)		
Section A in Team		-0.220	-0.071	-0.037	0.010	0.039
		(0.460)	(0.390)	(0.399)	(0.401)	(0.398)
Age		-0.447	-0.602**	-0.545*	-0.563*	-0.557*
		(0.313)	(0.298)	(0.317)	(0.329)	(0.325)
High School Grade			0.143***	0.145***	0.140***	0.142***
			(0.018)	(0.018)	(0.019)	(0.019)
Lyceum			1.008**	1.097**	1.083**	1.101**
			(0.406)	(0.435)	(0.436)	(0.436)
Expected Grade			0.170*	0.175*	0.175*	0.167*
			(0.094)	(0.093)	(0.093)	(0.093)
Parents' Education				0.005	0.002	-0.008
				(0.065)	(0.064)	(0.065)
Father: Employed				1.265**	1.238**	1.258**
				(0.519)	(0.534)	(0.534)
Mother: Employed				-0.734*	-0.711*	-0.680*
				(0.387)	(0.392)	(0.389)
Same Area				-0.491	-0.501	-0.532
				(0.428)	(0.435)	(0.433)
Absent Mate				0.212	0.137	0.637
				(0.487)	(0.500)	(0.575)
Female-Female					0.397	0.407
					(0.494)	(0.495)
Female-Male					0.327	0.258
					(0.623)	(0.621)
Male-Female					0.959	0.966
					(0.673)	(0.676)
Absent Mate*Socially Connected Team						-1.745*
						(1.024)
Constant	5.296***	14.787**	0.946	-1.133	-0.650	-0.806
	(0.280)	(6.931)	(7.181)	(7.685)	(8.145)	(8.035)
Observations	208	208	208	208	208	208
Adjusted R-squared	0.010	0.020	0.231	0.252	0.254	0.258

Notes: The Table reports OLS estimates. Dependent Variable: Grade at the team part. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

In Table 4 we investigate if students' "social popularity" affects their performance and if the treatment effect is robust with respect to these controls, since treatment could be correlated to the number of friends and social relationships. In the first column we estimate specification in column 5 of Table 3 and in addition control for the number of friends reported in our Survey, the number of received nominations and the number of mutual couples formed. None of these variables turn out to be significant while the impact of our treatment variable (and its statistical significance) is almost unchanged (+1.1). In columns 2-4 we control in turn for each of these variables separately, to avoid multicollinearity problems, since they are highly correlated. In all the specifications we do not find that these variables affect performance while we confirm that socially connected

teams perform significantly better.

Table 4. Social Connections and Team Performance: Controlling for the Intensity of Social Relationships. OLS estimates

	(1)	(2)	(3)	(4)
Socially Connected Team	1.172***	1.143***	1.239***	1.240***
	(0.433)	(0.431)	(0.426)	(0.427)
# Friends	0.338	0.405		
	(0.291)	(0.264)		
# Received Nominations	0.013		0.067	
	(0.093)		(0.068)	
# Mutual Couples	0.135			0.204
	(0.235)			(0.160)
Observations	208	208	208	208
Adjusted R-squared	0.255	0.259	0.253	0.257

Notes: The Table reports OLS estimates. Dependent Variable: Grade at the team part. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

Very similar results are found also when we estimate a Tobit model, which takes into account the fact that grades are left censored at 0 and right censored at 10. In Table 5 we replicate the first 5 specifications of Table 3 and in column 6 we estimate the specification in column 1 of Table 4: marginal effects of Tobit estimates turn out to be slightly larger than the OLS estimates.

Table 5. Tobit estimates of the Impact of Social Connections

	(1)	(2)	(3)	(4)	(5)	(6)
Socially Connected Team	0.988*	1.042*	1.372***	1.418***	1.605***	1.579***
	(0.579)	(0.577)	(0.483)	(0.470)	(0.535)	(0.542)
Observations	208	208	208	208	208	208
Pseudo R-squared	0.004	0.009	0.063	0.075	0.078	0.081

Notes: The Table reports Tobit estimates (marginal effects). Dependent Variable: Grade at the team part. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

The Italian University system allows students to sit the same exam as many times as they want without limits and without paying extra fees for further attempts. This induces some students, typically low ability students, to initially try to pass the exam providing low effort in studying. Being matched with a friend is not relevant or has a very small impact for these students as they would obtain a very low overall grade anyway (even with a fully cooperative mate). Thus, our total effect of social ties may be diluted by the presence of these students. To examine this aspect, in Table 6 we restrict the sample to students who have obtained at least a grade of 4 at the individual part of the exam (students who did not reach this level are likely to be students who just make a try to pass the exam). We replicate the same specifications reported in Table 3 on a sample of 155 students. Excluding "less motivated" students, the positive effect of social ties on team performance raises ranging from 1.12 to 1.52.

Table 6. Social Connections and Team Performance: OLS estimates. Restricted Sample Excluding Low Motivated Students

	(1)	(2)	(3)	(4)	(5)	(6)
Socially Connected Team	1.117**	1.166***	1.418***	1.455***	1.493***	1.521***
	(0.430)	(0.421)	(0.371)	(0.374)	(0.404)	(0.412)
Observations	155	155	155	155	155	155
Adjusted R-squared	0.041	0.041	0.225	0.266	0.275	0.262

Notes: The Table reports OLS estimates. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

All in all our estimates show that social ties increase students' performance in the team part of the test. The positive effect could be the result of either attenuated free-riding problems or positive spillovers among teammates. In the next section, by focusing on students' performance at the individual part, we are able to disentangle whether positive spillovers are actually enhanced by mutual friendship.

4. Socially Connected Teams and Individual Performance

Our experimental design does not allow us to understand whether students have effectively worked in teams, thus we are not able to distinguish how much of the total effect of social ties on team performance comes from free-riding attenuation or from positive spillovers due to teammates studying together and interacting in preparing the test. However, while free-riding is possible only for team performance, the effect of positive spillovers spreads across the two components of the test because a better understanding of any part of the course program improves the understanding of the other parts. Thus, if social ties help to enhance positive spillovers among teammates, socially connected teams should perform better than no socially connected teams also in the individual part of the intermediate test.

To shed light on this aspect, we consider as dependent variable the score students obtain at the individual part of the test, and estimate the same specifications reported in Table 3. Results are reported in Table 7. In the first two specifications, in which we do not include controls for students' ability, we find a positive but not statistically significant effect of being part of a socially connected team (*t*-stat=1.34). However, when we include among regressors our controls for individual abilities and family background (columns 3 and 4), we find that students coupled with one of their friends perform significantly better than control students also at the individual part of the test (+0.807, *t*-stat=2.16).In columns (5) and (6) we add controls for the gender composition of teams and controls for students ' social popularity and the effect of treatment remains almost unchanged.

Overall, the effect of being in a socially connected team on students' performance in the individual part ranges from 0.70 to 0.80 (on a basis of 6.17 it implies an increase in individual performance of 11%-13%). As expected, the estimated effect of social ties on individual performance tends to be lower than the effect on team performance, being absent the component of the effect due to the reduction in free-riding behavior and since

students are not supposed to study together the individual part.

Table 7. Social Connections and Student Performance at the Individual Part: OLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Socially Connected Team	0.526	0.576	0.807**	0.768**	0.784**	0.735*
	(0.432)	(0.428)	(0.373)	(0.376)	(0.384)	(0.389)
Section A in Team		-0.164	-0.044	-0.083	-0.080	-0.056
		(0.431)	(0.384)	(0.383)	(0.390)	(0.389)
Female		0.750*	0.271	0.208		
		(0.421)	(0.378)	(0.405)		
Age		-0.715**	-0.859***	-0.988***	-0.987***	-0.851***
		(0.319)	(0.314)	(0.315)	(0.329)	(0.294)
High School Grade			0.122***	0.125***	0.124***	0.125***
			(0.018)	(0.018)	(0.019)	(0.020)
Lyceum			0.881**	1.123***	1.122***	1.134***
			(0.376)	(0.414)	(0.416)	(0.408)
Expected Grade			0.111	0.114	0.114	0.135
			(0.094)	(0.092)	(0.093)	(0.093)
Parents' Education				-0.114*	-0.114*	-0.099
				(0.067)	(0.067)	(0.067)
Father: Employed				0.657	0.657	0.793
				(0.498)	(0.509)	(0.501)
Mother: Employed				-0.500	-0.499	-0.565
				(0.372)	(0.377)	(0.379)
Same Area				0.095	0.096	0.105
				(0.396)	(0.397)	(0.402)
Absent Mate				-0.313	-0.321	-0.352
				(0.526)	(0.529)	(0.528)
Female-Female					0.235	0.251
					(0.498)	(0.521)
Female-Male					0.258	0.243
					(0.581)	(0.611)
Male-Female					0.100	0.157
					(0.568)	(0.593)
# Friends						0.280
						(0.279)
# Received Nominations						-0.084
						(0.095)
# Mutual Couples						0.302
						(0.212)
Observations	208	208	208	208	208	208
Adjusted R-squared	0.004	0.031	0.194	0.209	0.201	0.207

Notes: The Table reports OLS estimates. Dependent Variable: Grade at the individual part Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

Furthermore, we have run the same estimates as in Table 7 by considering as dependent variable the overall grade obtained by students at the intermediate test: controlling for individual ability, being assigned to a socially connected team increases the overall grade by about 14-16% (see Appendix, Table A3).

The positive effect of social ties coming from interactions in learning activities among team members may persist also when students are not required to perform in team anymore. This may happen because they realize that working together is beneficial and continue to interact in studying activities or because the

knowledge acquired through interactions with mates when preparing the intermediate test is useful also for studying the remaining part of the course program. To investigate this aspect we consider students' performance at the final test (covering the second part of the course program), even if it was an individual test and was undertaken when our experiment was concluded. 173 students showed up at the final test, 88 belonging to the "socially connected team" group and 85 to the "no socially connected team" group.

As shown in Table 8, in which we replicate specifications of Table 3, the spillover effects of socially connected teams outlast the intermediate test: the assignment to a *Socially Connected Team* at the intermediate test affects students' performance also at the second test (ranging from 0.57 to 0.87) when they are evaluated exclusively on the basis of individual performance. The effect is generally statistically significant but smaller in magnitude compared to that found for performance at the intermediate test.

Table 8. Social Connections and Student Performance: OLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Socially Connected Team	0.574	0.693*	0.869**	0.844**	0.693**	0.694*
	(0.375)	(0.352)	(0.335)	(0.336)	(0.348)	(0.354)
Observations	173	173	173	173	173	173
Adjusted R-squared	0.011	0.054	0.152	0.153	0.182	0.167

Notes: The Table reports OLS estimates. Dependent Variable: Grade Final Test. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

5. Team ability heterogeneity and students' performance

As discussed by a number of recent papers on the topic, team performance might be affected by the composition of the team. In previous estimates we have already investigated the effects produced by the gender composition of teams. Another relevant dimension to investigate is team heterogeneity in terms of ability. According to Prat (2002) when the inputs provided by team members are complementary it is efficient to have team members of similar ability. On the other hand, if abler workers can impose high team production norms, and/or enable learning by less able members, heterogeneous teams can be efficient (Hamilton et al., 2003). Low ability workers might take high ability workers as role models and work harder when in team with them. It could also be that team heterogeneity in ability affects free-riding problems and the possibility to solve them through social pressure mechanisms.

Students' decision about the amount of effort to exert in studying the team part of the test may depend on their mate's ability. A student paired with a less able mate might either decide to devote less effort in studying the part of the course program evaluated on the basis of team performance as he\she anticipates a poor performance from his\her mate, or might want to help his\her less able mate and decide to exert more effort in order to compensate for the poor results that the mate might obtain. Similarly, a student paired with an abler

mate, in a cooperative setting, might increase his\her studying effort to reciprocate the good performance expected from his\her mate or might decide to free-ride. This is true both for treated and control students but treated students might react differently as they are supposed to care more for their mate.

Table 9. Social Connections, Team ability heterogeneity and Student Performance: OLS estimates

	(1) TREATED	(2) CONTROL	(3) TREATED	(4) CONTROL
Ability	1.0588***	1.6568***	0.8121***	1.5432***
	(0.2980)	(0.1887)	(0.3044)	(0.2315)
Diff_Ability_Pos	0.5796	-1.3362**	0.6735	-1.0148
	(0.4394)	(0.6619)	(0.4450)	(0.6891)
Diff_ability_Neg	0.5512	-0.6840	0.4734	-0.6307
	(0.3966)	(0.5335)	(0.4462)	(0.4854)
Section A in Team	0.1474	-0.1004	0.0027	-0.1461
	(0.6298)	(0.3894)	(0.5886)	(0.3807)
Female	0.1105	-0.3900		
	(0.5947)	(0.4930)		
Age	0.1652	-0.5943	0.2494	-0.2936
	(0.5566)	(0.4110)	(0.5833)	(0.3726)
Lyceum	1.7745***	0.5479	1.9105***	0.5217
	(0.6642)	(0.4987)	(0.6303)	(0.4963)
Parents' Education	-0.2379**	0.1888**	-0.2570**	0.1718**
	(0.1134)	(0.0753)	(0.1183)	(0.0749)
Father: Employed	2.1004**	0.1507	2.3625***	0.2838
	(0.8474)	(0.5998)	(0.8305)	(0.5430)
Mother: Employed	-0.2486	-0.8563*	-0.0717	-0.9053**
	(0.6533)	(0.4362)	(0.6822)	(0.4485)
Same Area	-0.6979	-0.9320*	-0.6912	-1.0329*
	(0.6926)	(0.5136)	(0.6673)	(0.5409)
Absent Mate	-1.5033*	0.9245	-1.7676*	0.7615
	(0.8923)	(0.5897)	(0.9760)	(0.5741)
Female-Female			0.1828	0.0184
			(0.6549)	(0.6448)
Female-Male			2.6454***	-0.9871
			(0.7018)	(0.6612)
Male-Female			1.9569*	0.3902
			(1.1524)	(0.6972)
# Friends			0.0751	0.2343
			(0.4472)	(0.3750)
# Received Nominations			0.1838	-0.0002
			(0.2113)	(0.1074)
# Mutual Couples			-0.4308	0.4442
			(0.3837)	(0.2880)
Constant	2.0904	16.8636*	-0.1070	7.9784
	(12.9138)	(9.0966)	(13.1215)	(8.6246)
Observations	105	103	105	103
Adjusted R-squared	0.229	0.298	0.259	0.328

Notes: The Table reports OLS estimates. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

Using our measures of individual ability *High School Grade* and *Expected Grade* we have undertaken a principal component analysis to obtain a comprehensive measure of individual ability (only the first component

was considered), which we call *Ability*. To investigate how the heterogeneity in team members ability affects team performance we have built the variable *Difference_Ability* computed as the difference between individual and mate's *Ability*. As students might react asymmetrically when they are less or more able than their mate, we have created two variables: the first one *Difference_Ability_Pos* is equal to *Difference_Ability* when *Difference_Ability*>=0 and 0 otherwise, while the other *Difference_Ability_Neg* is equal to the absolute value of *Difference_Ability* when *Difference_Ability*<0 and 0 otherwise. Then, we have interacted these variables with the dummy variable *Socially Connected Teams* to investigate differentiated effects according to treatment.

We have run separate regressions for treated and control students. As shown in columns 1 and 2, with a small set of control variables, students in no socially connected teams tend to provide less effort when their own level of ability is higher than that of their mates', while the effort of socially connected individuals does not depend on their mates' abilities. Similar results are found when we include among regressors a larger bunch of controls, but the negative effect for control students of being matched with less able peers becomes statistically insignificant.

7. Concluding Remarks

Teams and teamwork have been long used by firms, organizations and institutions. Although implemented to improve performance by allowing for knowledge spillovers between teammates, pay schemes based on aggregate measures of performance, such as team output, generate free-riding behaviors that involve efficiency losses due to subjects exerting less effort than with individual incentives.

With the aim of providing evidence on a causal relationship between social ties and team performance, not affected by self-selection issues, we have conducted a field experiment with university students engaged in studying activities for a college course, allowing us to observe individuals in a real life environment in which they have strong incentives to perform well.

Our experimental design allowed us to investigate whether social ties help to reduce free-riding and whether they induce positive spillovers among teammates. Our evidence suggests that social ties are relevant both for solving free-riding problems and for enhancing positive spillovers among teammates. Moreover, the positive effect of social ties coming from interactions in learning activities among team members persists also in the final test, where students are not required to perform in teams anymore.

APPENDIX

1. Determinants of students' participation at the exam

In this appendix we analyze the determinants of students' decision to show up at the intermediate test. This will serve also as a further check aimed at reassuring that randomization was successful in the subsample of students

effectively taking part in the. Estimation results from a linear probability model are reported in Table A1. We find that the decision to take the intermediate test is not affected by the assigned treatment group, instead males, students with higher *High School Grade* or with a higher expected grade are significantly more likely to effectively participate in the experiment by sitting the intermediate test.

Table A1. Probability of taking part to the exam (after having joined the experiment)

	(1)	(2)	(3)	(4)
Socially Connected Team	0.015	0.025	0.034	0.012
	(0.057)	(0.055)	(0.050)	(0.054)
Female		-0.125**	-0.131**	
		(0.053)	(0.052)	
Age		-0.005	0.022	0.022
		(0.043)	(0.043)	(0.043)
High School Grade		0.007**	0.000	0.001
		(0.003)	(0.002)	(0.002)
Lyceum		0.123**	0.105*	0.104*
		(0.053)	(0.053)	(0.053)
Expected Grade			0.053***	0.052***
			(0.011)	(0.011)
Parents' Education			-0.008	-0.008
			(0.008)	(0.008)
Father: Employed			0.005	0.006
			(0.068)	(0.068)
Mother: Employed			-0.046	-0.046
			(0.055)	(0.055)
Same Area			-0.074	-0.077
			(0.049)	(0.050)
# Friends			-0.041	-0.044
			(0.035)	(0.035)
Section A in Team			0.074	0.071
			(0.050)	(0.050)
# Received Nominations			0.026**	0.025**
			(0.012)	(0.012)
# Mutual Couples			0.039	0.041
			(0.029)	(0.029)
Female-Female				-0.165***
				(0.058)
Female-Male				-0.202**
				(0.088)
Male-Female				-0.119
				(0.076)
Constant	0.792***	0.339	-0.956	-0.925
	(0.036)	(0.899)	(1.039)	(1.047)
Observations	260	260	260	260
R-squared	0.000	0.056	0.208	0.217

Notes: The Table reports OLS estimates. The dependent variable is *Present*. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

2. Evaluating the Impact of Teamwork

To investigate the effect produced on students' performance by being evaluated under an equal sharing rule compared with a piece-rate rule, we stack the data at the exam level and consider two observations for each student pertaining to his/her performance at the team part and at the individual part of the test, respectively.

Table 2A. A Comparison of Performance in Team and at the Individual Part

	(1)	(2)	(3)	(4)	(5)
Team	-0.502***	-0.502***	-0.502***	-0.502***	-0.502***
	(0.144)	(0.144)	(0.145)	(0.146)	(0.146)
Section A in Team	-0.224	-0.100	-0.119	-0.098	-0.104
	(0.381)	(0.338)	(0.341)	(0.343)	(0.342)
Female	0.665	0.142	0.069		
	(0.379)	(0.335)	(0.336)		
Age		-0.722*	-0.766*	-0.793*	-0.655*
		(0.293)	(0.310)	(0.313)	(0.295)
High School Grade		0.126***	0.127***	0.126***	0.126***
		(0.018)	(0.018)	(0.019)	(0.020)
Lyceum		0.880*	1.076**	1.073**	1.103**
		(0.355)	(0.370)	(0.371)	(0.361)
Expected Grade		0.154	0.154	0.149	0.159
		(0.085)	(0.083)	(0.084)	(0.085)
Parents' Education			-0.063	-0.066	-0.053
			(0.058)	(0.058)	(0.058)
Father: Employed			0.930*	0.893	1.026*
			(0.452)	(0.460)	(0.457)
Mother: Employed			-0.546	-0.527	-0.580
			(0.346)	(0.350)	(0.352)
Same Area			-0.257	-0.285	-0.259
			(0.336)	(0.341)	(0.340)
Absent Mate			-0.340	-0.346	-0.365
			(0.455)	(0.460)	(0.462)
Female-Female				0.218	0.304
				(0.418)	(0.434)
Female-Male				-0.118	-0.031
				(0.516)	(0.538)
Male-Female				0.197	0.281
				(0.539)	(0.553)
# Friends					0.403
					(0.284)
# Received Nominations					-0.039
					(0.087)
# Mutual Couples					0.197
					(0.191)
Constant	5.940***	6.582	7.747	8.590	2.747
	(0.369)	(6.876)	(7.381)	(7.588)	(7.404)
Observations	416	416	416	416	416
Adjusted R-squared	0.015	0.205	0.224	0.222	0.233

Notes: The Table reports OLS estimates. Standard errors (corrected for heteroskedasticity and allowed for clustering at the individual level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

With this aim, we build the variable *Grade*, that takes the values of *Grade Team Part* for the performance at the team part and *Grade Individual Part* for students' performance at the individual part of the test. We build the variable *Team* for the part carried out under team work. We estimate a model for *Grade* and this allows us to compare the performance of students under the two different evaluation rules. This is possible since we assigned randomly to students the parts of the program to study under individual and team work.

OLS estimates are reported in Table A2. Standard Errors are in these specifications allowed for clustering at the individual level, since we have two observations for each student. In all the specifications we consider the *Team* dummy and we control for *Section A in Team* to take into account for any eventual difference in the difficulty of different program sections.

In all the specifications we find that students perform significantly worse when engaged in team work with respect to individual work.

3. Effects of Social Connections on the Overall Grade of the intermediate test

Table A3 reports the effect produced by being part of a *Socially Connected Team* on the *Overall Grade* obtained by students at the intermediate test (*Overall Grade=(Team Grade+Individual Grade)/2*). We find similar effects of those that we found on *Team Grade* and on the *Individual Grade*.

Table A3. Social Connections and Student Performance: OLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Socially Connected Team	0.596	0.646	0.888**	0.879**	0.930**	0.881**
	(0.419)	(0.415)	(0.347)	(0.351)	(0.375)	(0.380)
Observations	208	208	208	208	208	208
Adjusted R-squared	0.007	0.032	0.236	0.249	0.243	0.249

Notes: The Table reports OLS estimates. Dependent variable: Overall Grade. Standard errors (corrected for heteroskedasticity and allowed for clustering at the team level) are reported in parentheses. The symbols ***, **, * indicate that the coefficients are statistically significant at the 1, 5 and 10 percent level, respectively.

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