Should you compete or cooperate with your schoolmates?

Massimiliano Bratti, Daniele Checchi, Antonio Filippin
University of Milan and IZA†

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Abstract

This paper presents empirical evidence from the PISA 2003 survey on the role of students' attitudes towards competition and cooperation in mathematical literacy achievement. While individual competitive attitudes are positively correlated with test scores, the reverse occurs when considering the aggregation of individual attitudes. Similarly, while individual cooperative attitudes exhibit a negative correlation with test scores, the opposite is true in the aggregate. We provide an interpretation of this "fallacy of composition" based on public good production and incentives to free riding, which is prevented by social norms held valid in small groups.

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† Address correspondence to Antonio Filippin, University of Milan, Department of Economics, via Conservatorio 7, 20122 Milano, Italy. Email: antonio.filippin@unimi.it. We would like to thank Vasilis Koulaidis and Denis Meuret for helpful suggestions. We also thank the participants at the "4th Symposium of the Network Economics of Education and Education Policy in Europe" (Madrid), at the conference "Education, Equity and Social Justice" (Prague), at the IWAEE workshop (Catanzaro), at the conferences of the EALE (Amsterdam) and EEA (Milan), and in the seminars held at the University of Milan and at the University of Bolzano for their comments. The usual disclaimer applies.

1. Introduction

The standard application of the educational production function approach correlates student competences to parental background, school resources, and peer effects, which are considered as inputs (Hanushek and Woessmann, 2010). Less attention is devoted to students' attitudes, which in general are generated by the interaction between the teacher and the class. In this paper we provide robust empirical evidence that these attitudes matter for explaining within-school variation in student achievement. In particular, we focus on cooperative or competitive attitudes, as self-reported by the students, an area of investigation that is often covered by educationalists.[1]

While the learning process may be affected both by intrinsic and by extrinsic motivations (Malone and Lepper, 1987), educationalists usually consider intrinsic motivation as more effective than the extrinsic one in enhancing the acquisition of knowledge, and in a parallel fashion they regard group learning as more effective than individual learning. For instance, Shachar and Fischer (2004) claim that group investigation is "designed to enhance intrinsic motivation by virtue of its emphasis on a high level of student autonomy and responsibility in making decisions regarding the selection and implementation of study projects [...], as well as receiving and offering considerable support from, and assistance to, group-mates". In addition, group work requires caring for others, thus reinforcing the sense of community belonging.[2] Discussing with classmates

[1] See Abrami et al. (2000) and Watkins (2005) for a thorough review of the literature.
[2] See for instance Watkins (2005) and Cowie and Berdondini (2001).

involves reconciliation of multiple perspectives through the medium of dialogue, and this collaboration develops a higher abstraction and elaboration skills.

Moreover, group activity allows for individualised attention for low achieving students, as well as providing high achievers with an opportunity to improve their understanding of the subject while illustrating it to the group. In group learning students of different abilities obtain a personalised motivation, provided that group composition does not mix extremes that are too far apart. Students with different levels of achievement have different attitudes to group learning. Rather common in this stream of literature are the findings that low achievers seem to gain more from group learning than high achievers, and that high achievers are more inclined to gain recognition of their level of ability through competition in the class.[3]

Increasing empirical evidence suggests that group learning yields superior outcomes in terms of students' motivation and achievement. Whatever teaching technique is adopted in a class, and irrespective of the students' age or subject taught, most of the literature stresses the advantages of cooperative learning.[4] According to the advocates of this approach, the main advantage of passing from a teacher-centred learning (namely "learning = being taught") to group learning

[3] See Shachar and Fischer (2004), p.83.

[4] Zammuner (1995) reports evidence of text quality of individual writing Vs. dyadic writing/revision in an experiment conducted among 4th graders. She finds higher quality improvement under individual writing and dyadic revision. Hanze and Berger (2007) study the impact of the jigsaw cooperative learning method (i.e. when each student is assigned a specific task in group activity) in 12th grade physics classes, showing positive effects on intrinsic motivation, experience of competence (especially among low achievers) and activation of deeper level processing.

is exactly the appeal to individual intrinsic motivation for learning ("learning = individual sense-making", according to Watkins, 2005).

Cooperative learning, however, is not a spontaneous phenomenon:

> *Effective group work requires students to share ideas, take risks, disagree with and listen to others, and generate and reconcile points of view. These norms do not necessarily pervade classrooms. Students are used to working individually, being rewarded for right answers, and competing with each other for grades. ... One problem is failure to contribute. When groups create a single product and receive one grade, students sometimes do not do their fair share.* (Blumenfeld et al., 1996, p.38).

As the quotation makes it clear, groups work according to implicit or explicit norms that regulate individual contributions and individual accountability is essential to ensure generalised cooperation.

As economists, not only are we particularly sensitive to the caveat raised by the quotation above, but we are also tempted to stress the role of explicit incentives as represented by extrinsic motivations. Summarizing the previous literature, we cannot miss the strong similarities that learning in groups has with the provision of public goods. Group learning has positive externalities, since all students seem to improve their achievements. However, individual incentives favour free riding and these incentives are increasing in student's ability, since the most brilliant students are those who contribute more to group learning, with a greater benefit for the "worst" (i.e., the less able) ones. Group norms may reverse individual incentives, but they are highly dependent on the environment. In fact, the emergence of cooperation is influenced by the socio-cultural environment where learning takes place. The environment shapes the incentives and the attitudes of participants, rewards or penalises the leaders, reinforces or weakens stereotypes.

In the sequel, we follow an alternative route to verify these intuitions. Instead of observing purposely arranged experiments of teaching styles, we resort to students self-declared attitudes with respect to cooperation or competition in class-work, and we study the correlation with individual achievement, as measured by test scores. As long as students' attitudes are a good proxy for the actual behaviour of students and test scores are good proxies for actual learning, we may draw inference on the impact of cooperation onto learning. However, we consider the possibility of divergence between individual and social optimum, because it may be personally convenient to act in a competitive manner while the others are open to cooperation: think of receiving solutions to test by cooperative classmates, while not reciprocating. This opens the door to a fallacy of composition, because as long as all students behave in the same way, none will pass solutions to others.

In the present paper, we use data from the 2003 wave of the OECD's *Programme for International Student Assessment* (PISA), which gathers comparable information on students enrolled in schools located in many different countries and provides a standardized measure of student competences (our proxy of learning). We make use of the 2003 survey, because it contains an array of questions regarding students' attitudes towards cooperation and competition that have not been replicated in the 2006 survey. Although such a dataset does not allow us to observe the process that effectively takes place in the class, it has the great advantage of providing a large scale analysis based on a standardized measure of performance, while pedagogical and psychological literature usually relies on small case studies. We study the correlation between students' attitudes and performance, showing that there is an individual incentive to compete, but a group advantage in adopting cooperative strategies. This result is robust against alternative specifications. We also show that attitudes affect learning with differential intensity, according to the environment experienced in class (size, homogeneity, teacher attitudes).

In the second part, we put forward a possible interpretation of our empirical findings, by proposing a model where each student allocates his/her effort between two types of activity, cooperation or competition. Cooperation provides positive externalities in terms of knowledge to the entire group of students irrespective of individual contribution. Competition has a private return only, which is increasing in ability. As a consequence, under spontaneous ordering there is an excess of competition and limited cooperation. However, when group norms are modified (for instance because a teacher may favour group learning or because peers penalize selfish behaviour), these conclusions can be reversed.

2. Empirical analysis

The OECD's PISA surveys are designed to collect information on real-life competences from 15-year-old students, on a comparable cross-country base. These surveys are conducted every three years, and cover reading, mathematical and scientific literacy, and problem solving, with a dominant area in each wave. The 2003 wave has been conducted in 41 countries with a primary focus on mathematical literacy. The PISA survey provides an extremely rich set of explanatory variables that can be linked to students' performance, ranging from individual characteristics and family background, to characteristics of the school and of national educational systems.

In the 2003 PISA questionnaire there are also some questions concerning students' learning approach. Two sets of questions concern their preference for competitive learning[5] and cooperative learning[6] respectively, which are not mutually exclusive. In fact, it may well be that a student wants to outperform his/her classmates and at the same time has preferences for cooperative learning. This information about students' learning attitudes has been summarised by the

[5] Students have to assess how much they agree with the following statements (questions n.37a-37c-37e-37g-37j):
-I would like to be the best in my class in mathematics
-I try very hard in mathematics because I want to do better in the exams than the others
-I make a real effort in mathematics because I want to be one of the best
-In mathematics I always try to do better than the other students in my class
-I do my best work in mathematics when I try to do better than others.

[6] Students have to assess how much they agree with the following statements (question n.37b-37d-37f-37h-37i):
-In mathematics I enjoy working with other students in groups
-When we work on a project in mathematics, I think that it is a good idea to combine the ideas of all the students in a group
-I do my best work in mathematics when I work with other students
-In mathematics, I enjoy helping others to work well in a group
-In mathematics I learn most when I work with other students in my class.

OECD researchers (using principal component analysis) into two variables (COOPLRN and COMPLRN – see Pisa 2004).

PISA surveyed students by schools and not by classes, with an average of 33 students tested per school. In the following analysis we consider school averages as the best available proxy of class averages. We use students' test scores as a measure of the knowledge possessed by each student.[7] For each student in the sample we compute the average attitude in the school towards competitive and cooperative learning, excluding his/her own opinion.

From the original dataset (276,165 observations), we drop countries where the distribution of test scores is too dissimilar from the rest of the sample (65,393 cases excluded) and/or there are missing information (59,727 observations with at least one missing in one of the relevant regressors).[8] After excluding individuals in schools with less than 10 students (3,301 observations), we also omit students not enrolled in the modal grade (37,807 observations), because they could represent rather peculiar sub-samples (either in terms of ability, or in terms of attitudes towards cooperating with others, for instance repeating students might face rather dissimilar peers). Finally, we are left with 111,684 students spanning 33 countries; descriptive statistics are summarized in Table 1, while Table 2 displays average student attitudes by country, where the

[7] Actually, PISA data contain five plausible values for each student, since each student was tested on a subsample of questions. We use here the average across the five plausible values.
[8] The countries excluded for not possessing at least 10% of students in the top quartile are Brazil, Indonesia, Thailand, Tunisia, Uruguay and Yugoslavia. France is excluded because does not contains information on school size and student/teacher ratios.

international mean has by construction been set equal to zero and the standard deviation to one).

We know from the extensive literature on student performance (see among others Wößmann, 2003, Ammermüller, 2005) that individual test scores are positively correlated with a number of variables, although scholars disagree about their causal interpretation in some cases (see for instance Hanushek, 1997, vs. Greenwald et al., 1996, on the role played by school resources). Among such variables there are family background (parental education, parental socio-economic status, number of books at home, internet connected computer at home, proxy for durables possession), some proxies of school resources (instructional time, number of computers, class size) and some institutional indicators (existence of central exit examination systems, source of funding).

In Table 3 we report OLS estimates of the correlation of students' test scores, measures of family background and our measure of attitudes. Country fixed effects are included; heteroskedastic robust standard errors are clustered by schools. In column 1 we consider the individual attributes replicating known results: girls are worse than boys in numeracy; age (measured in months, since they are all 15 year old) is associated to better performance; parental background (measured by parental occupational status, parental years of education – linear and squared, possession of durables – including books and internet-connected computers) is positively associated to students' tests. We also include a proxy of individual effort, which is given by the amount of hours per week spent on "homework or other study set by your teachers".

Potential self-selection into schools is dealt with in column 2: we add student/teacher ratio (as proxy for available resources), which affects competences though with a low magnitude and math class size (which is positively associated to learning up to a size of 43 students). We also consider the possibility of self-selection by family background in schools, especially in countries where the secondary school level is tracked, by including the average occupational prestige and education of parents in the school, which come out both positively and significantly associated with student scores. Eventually, we include two measures of the math teaching styles adopted in the school (and reported by the school head): whether in order to promote students' engagement with mathematics the school promote mathematics competition and/or mathematics clubs. The former activity should stimulate competitive attitudes among the students, while the latter should spur cooperative behaviour (at least among the club members). Both variables, which may also be proxies of the general interest of the school in mathematical activities and performance, are positively associated with test scores, with similar magnitudes of impact.[9]

We now introduce student self-reported attitudes in column 3 of Table 3. Students expressing competitive attitudes have a higher average performance,

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[9] Math competition is applied in more than 90% of schools in Australia (98%), Latvia (97%), New Zealand (95%), Poland (98%), Russian Federation (95%) and Slovakia (97%). Math clubs are much less frequent, being recorded in Hong Kong (92%), Luxemburg (61%), US and Russian Federation (51%).

while the opposite occurs for those more in favour of group activity. In other words, at the individual level, even after controlling for teaching styles, there is a prize associated to being competitive while being cooperative implies a penalty. However, we obtain a reversal of this intuition in column 4, once we introduce the average attitudes expressed by the students in the school (computed excluding his/her own attitude). Other things being equal, students in schools where competitive attitudes are prevalent achieve lower average test performance, while the opposite situation is observed when cooperative attitudes towards learning prevail.

In order to appreciate the overall impact of attitudes, let us consider the following thought experiment. If we start from a neutral situation (all students express no preference for either cooperative or cooperative attitudes, i.e. COOPLRN=COMPLRN=0) and we observe a one standard deviation (unitary) increase in (all) students preferences towards competition, we will obtain an overall increase in test score of +1.76 (as a result of +9.45–7.69). On the contrary, if we simultaneously increase preferences for cooperative learning we obtain an increase of +4.68 (as a result of –4.35+9.03), which is twice and half the previous effect. Thus we confirm the finding of the educationalist literature reported above: promoting cooperative attitudes among students is more beneficial than promoting competition, at least in terms of competences as measured by average test scores.

In the provision of a public good incentives to free ride increase with the number of agents because the returns to contributions become more and more diluted. Therefore, we have explored whether the previous findings change if we add the interaction between class size and individual and average attitudes to the specification of column 4. The results are shown in Figure 1, where marginal effects are computed for different class sizes and for unitary values for either competitive (both at individual level and at school average level) or cooperative attitudes. The graph shows that for small groups of students cooperative attitudes tend to be associated to higher gains in terms of test scores than competitive ones. When the group size crosses the threshold of 22 students the reverse situation applies. This suggests that incentives to adopt cooperative behaviours are stronger under strong personal ties, which are likely to be more frequent in small groups. Similar results are obtained when we use student/teacher ratio as an alternative proxy for group size.

Stronger personal ties are likely to depend not only on the size but also on the homogeneity of the group. If we divide countries between comprehensive secondary school systems and tracked ones, we expect larger within-school heterogeneity in the former group, because in the latter students can self-select into more homogenous groups. In fact, we observe greater gains from cooperative attitudes in tracked countries, as illustrated by Figure 1.

We have considered various robustness checks. In the first one we re-estimate the model in column 4 of Table 3 in 50 random extractions of 50 percent of observations (without replacement) from the original sample, and we always obtain coefficients on attitudes that are statistically significant and with the same sign and very similar magnitudes. The results are also robust to allowing coefficients on all covariates but those on the four attitude variables to vary by country. In the third check, we replicate the same estimates country by country, allowing also the coefficients on attitudes to vary. Some country samples turn out to be rather small. Out of 33 estimated coefficients for each individual and average attitude, we find more persistent effects on individual attitudes: for individual competitive attitudes 29 coefficients have positive and significant coefficients, while for individual cooperative attitudes 22 coefficients are negative and significant, whereas 6 are negative but not significant. When considering average attitudes, only 14 coefficients are significant and consistent with the pooled regression, while 7 are significant but have the wrong sign. Overall, out of 132 coefficients on attitudes, 65 are significant and consistent with the pooled regression and 11 are significant and have the opposite sign, the rest being statistically insignificant at usual criteria.[10]

In general, we do not give to coefficients on attitudes a causal interpretation. Indeed, students' time/effort allocation to the production of public and private knowledge is likely to depend on their ability, which also affects their

[10] Seven out of eleven "wrong" coefficients are obtained in four countries: Hong Kong (China), Japan, Korea and Turkey, suggesting country specificities in Easter Asia. Despite common beliefs that Confucian heritage favours cooperation, Phuong-Mai et al. (2005) show that this culture itself creates an obstacle to effective cooperation in learning. Country regressions available from the authors.

performance.[11] Hence, student behaviour is likely to be endogenous, and we may accordingly expect a positive spurious correlation between individual competitive attitudes and performance driven by student individual ability. However, our result of a positive correlation between average cooperative behaviour and mathematical literacy is not easily predicted by the same argument, i.e. average ability within the group (note that signs are inverted with respect to individual attitudes), and we maintain that this is likely to partly reflect a true effect of average attitudes on student performance. We tried to implement an instrumental variables strategy to tackle this problem but, unfortunately, PISA 2003 data do not provide a sufficient number of variables suitable for the identification of the four potentially endogenous variables we are dealing with.

Finally, we tested whether competitive and cooperative attitudes have a different impact at different quantiles (25th, 50th and 75th percentiles) of student's knowledge (which is correlated to unobservable components of ability once we control for family background according to our model). When considering comprehensive educational systems, we observe that competitive attitudes display returns that are increasing in ability, while the opposite applies to cooperative attitudes. Thus, other things being constant, the "best" students have a higher individual return to competition, while the "worst" ones have lower disincentives when preferring cooperative learning. As far as tracked educational systems are concerned, incentives to individual competitive behaviour are lower

[11] This feature is also captured by the theoretical model in section 3, see equation (8).

and roughly constant in student performance, while disincentives for individual cooperative attitudes disappear irrespective of the students' level of knowledge.[12]

3. A suggested interpretation

In this section we show that most of our empirical results can be rationalised in a framework of individual rational choice of each student, facing the existence of an externality in knowledge formation. As long as the acquisition of knowledge encompasses features typical of the provision of a public good, we can replicate a divergence between individual and collective optima. We start by postulating that each student cares about his/her optimal level of knowledge, and faces the problem of allocating his/her time and/or effort between individual work and collective work.[13] We assume that *private knowledge* is produced through time/effort allocated to individual learning, while *public knowledge* is achieved through learning in a group, which requires sharing knowledge with others. The simplest way of formalizing such an idea is the following:

$$U_i = \alpha_i p_i + \tilde{s} - \frac{1}{2}(p_i)^2 - \frac{1}{2}(s_i)^2 \qquad (1)$$

[12] These additional results are available from the authors upon request.

[13] We partly deviate from the educational literature previously outlined, which views "cooperative learning" as an activity mainly taking place in class and induced by teachers. We implicitly refer to situations where students are free to choose how to allocate their time/effort and whether to work alone or in groups. Therefore, it mainly applies to study time outside class hours, including for instance student homework done in group.

where U_i is individual utility, p_i is the time/effort devoted to individual learning by student i, whose ability is α_i. The interaction $\alpha_i p_i$ represents what we term *private knowledge*, i.e. what students learn on their own.[14] The time devoted to group learning (s_i) generates instead *public knowledge* ($\tilde{s}$), defined as

$$\tilde{s} = \frac{1}{\sigma_\alpha n} \sum_{i=1}^{n} \alpha_i s_i \; . \qquad (2)$$

Consistently with the empirical evidence, we assume that the production of public knowledge is decreasing in students' heterogeneity represented by the standard deviation of their ability in the class, σ_α. A possible interpretation is that peer effects are more intense in more homogenous groups.

If we define a learning approach as *cooperative* when a larger amount of time/effort is devoted to the production of public rather than private knowledge, i.e. when $s_i^* > p_i^*$, the first order conditions would imply that all the students would optimally choose to be competitive. In fact, the following optimal choices emerge:

$$\arg\max_{p_i} [U_i] = p_i^* = \alpha_i \qquad (3)$$

[14] The disutility of learning is modelled separately for private and public knowledge to ensure the existence of internal solutions. Notice that we are shifting from students' attitudes towards cooperation/competition (as recorded in the empirical analysis) to a choice variable in terms of time/effort allocation in our sketch model presented here.

$$\arg\max_{s_i}[U_i] = s_i^* = \frac{\alpha_i}{\sigma_\alpha n} \tag{4}$$

with the contribution to public knowledge that decreases in students' heterogeneity and group size, approaching zero when the number of students becomes very large.[15] Abler students are those who put more time/effort in both types of learning, and less able students are those who benefit more from public knowledge whenever its amount is positive (since they obtain more public knowledge than they contribute to), rationalizing the idea that less able students are more inclined to cooperative learning because they benefit more from it.

But the prediction of zero time/effort contribution to cooperative learning is disconfirmed by the empirical evidence, and therefore we need to revise our set-up in order to rationalize actual behaviours of students. One possibility is to assume that students enjoy cooperative learning because they like interacting with their classmates. Alternatively, a selfish behaviour in terms of learning could likely be punished in terms of exclusion from the social activities inside and outside the class:

$$U_i = \alpha_i p_i + \tilde{s} - \frac{1}{2}(p_i)^2 - \frac{1}{2}(s_i)^2 - \mu(p_i - s_i), \quad \mu > 0. \tag{5}$$

[15] Notice that $p^* > s^*$ whenever cooperation has a fostering effect on knowledge, i.e. when $\sigma_\alpha n < 1$.

The last term indicates that a cooperative learning approach ($s_i > p_i$) generates a good reputation among the classmates, therefore implying a positive utility, while the opposite holds when a competitive learning approach ($p_i > s_i$) is chosen. The optimal amounts now become respectively:

$$\arg\max_{p_i}[U_i] = p_i^* = \alpha_i - \mu \tag{6}$$

$$\arg\max_{s_i}[U_i] = s_i^* = \frac{\alpha_i}{\sigma_\alpha n} + \mu \,. \tag{7}$$

The opinion of classmates, modelled in this simple way, has the effect of shifting time/effort from competitive to cooperative learning without changing the overall amount of time devoted to studying.

The threshold level of ability that divides the students characterized by competitive learning approach from those characterized by cooperative learning is obtained by equating equations (6) and (7). *Competitive learning* occurs for all students characterised by a level of ability

$$\alpha_i > \frac{\sigma_\alpha n}{\sigma_\alpha n - 1} 2\mu \,, \tag{8}$$

which is increasing in the strength of classmates' beliefs, and decreasing in the degree of heterogeneity (σ_α) and the size (n) of the group. Therefore, other things being constant the model rationalizes a positive correlation between ability and propensity to adopt a *competitive learning* approach.

Now let us see what happens to the amount of knowledge of the whole class, as measured for instance by a standardized test that is comparable across different classes. We define the total knowledge K of a class simply as the sum of the total knowledge acquired by each student, recalling that individual total knowledge is the sum of individual learning $(\alpha_i p_i)$ and shared knowledge $(\tilde{s})$. Notice that public knowledge affects the outcome of every student, irrespective of both individual participation in group activities and individual ability. In this way, the public knowledge $\tilde{s}$ is counted n times when computing the score of the class. Therefore, the total knowledge of a class is by construction increasing in the degree of cooperation within the class, matching empirical evidence that students performance is increasing with aggregate cooperation.[16] The stronger the social preferences for cooperation, the larger the amount of public knowledge produced and therefore the larger the amount of total knowledge.

If we accept that in more homogeneous environments the opinion of classmates is likely to be more relevant, we expect to observe that tracked educational systems, characterized by a more homogeneous student intake within schools, should display a relatively higher degree of cooperation and a lower degree of competition. Moreover, since we believe that group working is more productive

[16] When class size is sufficiently large, and reputation about being a cooperative person is irrelevant, a purely competitive outcome emerges with individual contribution to public knowledge going to zero: as a consequence also public knowledge is equal to zero.

when involving extremes that are not too far apart (for instance in terms of ability), we have modelled public knowledge as a decreasing function of students' heterogeneity (see equation (2)). Therefore, the model also rationalizes that tracked educational systems should display a higher return to aggregate cooperative behaviour, in line with empirical evidence.

Summing up, we have shown that it is possible to rationalize the fallacy of composition that we have highlighted in the previous section. Whenever individuals are to allocating their time/effort between privately rewarded and spill-over generating activities, they do prefer the former (like individual learning). If we take into account the loss in terms of social reputation associated to individual behaviour, however, results may be reversed.

4. Conclusions

In the present paper, we show another occurrence of "failure of composition". Using a survey conducted in 2003 by the OECD-PISA consortium, we exploit attitudes towards competitive or cooperative learning. We study the correlation between these attitudes, family background and student test scores. When controlling for different aspects of family background and school resources, we show that test scores are positively correlated with competitive attitudes and negatively correlated with cooperative ones. However, the situation is reverted when we take into account the peers' attitudes: learning in a competitive environment is detrimental to average knowledge, while a cooperative environment favours average performance. This counterintuitive result holds stronger the smaller is the class size.

We also show that these findings are strengthened in more homogenous environments as represented by tracked educational systems, because we provide evidence that those systems raise substantially the returns to cooperation both at individual and at aggregate level, probably thanks to a greater homogeneity of the student intake.

Most of such findings can be rationalized by a simple theoretical model that compares the production of knowledge to the provision of a public good, showing that private incentives do not necessarily coincide with public ones. In such a framework (where public knowledge represents the public good at hand) this leads to a suboptimal provision of cooperation, due to free riding incentives.

The free riding problem is attenuated whenever reputation among peers is relevant for the individual and/or when heterogeneity in group abilities is limited. The first effect is obtained by means of a positive utility impact of cooperative behaviour via classmates' opinions, while the second derives from the assumption that the production of public knowledge is decreasing in heterogeneity of the group.

The model also rationalizes the idea that the "best" students are characterized by a competitive learning approach, while the opposite holds for the less talented students, and that students' knowledge increases with individual competitive behaviour and with average cooperative behaviour. Moreover, tracked educational systems should display a relatively higher degree of cooperation and a lower degree of competition, as well as a higher return to cooperation.

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Tables and Figures

Table 1 - Descriptive statistics – PISA 2003

Variable	Obs	Mean	Std. Dev.	Min	Max
Test score in mathematics	111684	526.66	85.78	200.0623	848.9952
Female	111684	0.51	0.50	0	1
Age	111684	15.80	0.29	15.17	16.42
Highest parental occupational status	111684	50.22	16.18	16	90
Highest parental education in years of schooling	111684	13.27	3.05	0	17
Computer facilities at home	111684	0.14	0.95	-1.6763	1.0513
Index of home possessions	111684	0.13	0.92	-3.7872	1.9396
Hours all homework	111684	6.46	5.78	0	30
How many books at home	111684	3.68	1.36	1	6
Student/teacher ratio	111684	13.49	4.87	1.379	70
How many students attend math class	111684	23.40	7.40	1	80
School size	111684	720.62	464.39	19	6000
Math clubs to promote engagement in the school	111684	0.19	0.40	0	1
Math competitions to promote engagement in sch.	111684	0.69	0.46	0	1
Competitive learning (student attitude)	111684	-0.02	0.95	-2.8441	2.4495
Co-operative learning (student attitude)	111684	0.00	0.96	-3.1339	2.7415
Tracking	111684	0.49	0.50	0	1

* Countries classified as tracked according to the distribution of the type of secondary school attended (variable PROGN): Austria, Belgium, Czech Republic, Germany, Greece, Hong Kong (China), Hungary, Ireland, Italy, Japan, Korea, Luxemburg, Macao (China), Netherlands, Portugal, Russian Federation, Slovakia, Spain and Turkey.

Table 2 – Students attitudes by countries included in the analysis – PISA 2003

Observations	observations	competitive (mean)	cooperative (mean)
Australia	7315	0.29	0.07
Austria	1787	-0.33	0.01
Belgium	4833	-0.38	-0.06
Canada	13094	0.17	0.16
Czech Republic	2632	-0.15	-0.06
Denmark	2551	-0.05	0.25
Finland	4526	-0.32	-0.15
Germany	1899	-0.04	0.02
Greece	2534	0.28	0.17
Hong Kong (China)	2259	0.07	-0.02
Hungary	2314	-0.44	-0.11
Iceland	2502	0.28	-0.28
Ireland	1480	0.08	-0.12
Italy	8264	-0.10	0.08
Japan	3479	-0.44	-0.69
Korea	4243	-0.04	-0.77
Latvia	2751	-0.11	-0.15
Liechtenstein	198	-0.21	0.22
Luxembourg	1351	0.02	-0.11
Macao (China)	339	0.02	0.14
Netherlands	1191	-0.44	-0.14
New Zealand	2549	0.14	0.15
Norway	2628	-0.30	0.02
Poland	3896	0.10	0.12
Portugal	2275	-0.08	0.35
Russian Federation	3089	-0.09	-0.08
Slovakia	3622	0.02	0.23
Spain	5771	0.04	0.11
Sweden	3511	-0.04	-0.20
Switzerland	4288	-0.33	0.18
Turkey	1553	0.67	0.33
United Kingdom	4846	0.19	0.13
United States	2114	0.38	0.27
Entire sample	111684	-0.02	0.00

Table 3 – Performance in math tests – PISA 2003

	individual controls 1	school controls 2	individual attitudes 3	school attitudes 4
Female	-18.886***	-19.612***	-16.894***	-17.286***
Age of student	1.855**	2.181**	2.229***	2.155**
Highest parental occupational status	0.742***	0.408***	0.405***	0.404***
Highest parental education in years of schooling	1.424***	1.32***	1.48***	1.446***
Highest parental education squared	0	-0.058***	-0.068***	-0.067***
Computer facilities at home	7.03***	5.908***	5.831***	5.797***
Index of home possessions	7.314***	4.63***	4.155***	4.226***
Hours All homework	1.479***	0.984***	0.829***	0.836***
How many books at home	12.152***	10.738***	10.784***	10.72***
Average school occupational prestige		1.746***	1.771***	1.779***
Average school parental education		6.734***	6.887***	6.972***
Student/teacher ratio		-0.711***	-0.729***	-0.727***
School size		-0.001	-0.001	-0.001
How many students attend math class		3.586***	3.659***	3.623***
How many students attend math class squared		-0.041***	-0.043***	-0.042***
Teaching style: math.club		5.731***	5.567***	5.626***
Teaching style: math.competition		5.505***	5.445***	5.44***
Co-operative attitudes			-4.146***	-4.35***
Competitive attitudes			9.216***	9.454***
School average cooperative attitude				9.036***
School average competitive attitude				-7.691***
Observations	111684	111684	111684	111684
R^2	0.26	0.32	0.33	0.33
Log likelihood	-638948	-634332	-633589	-633530

* significant at 10%; ** significant at 5%; *** significant at 1%
errors clustered by school– country fixed effects included

Figure 1 – Interactions effects