Should you compete or cooperate with your classmates ?

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Abstract:

This paper reviews some recent literature from education studies, which claims that cooperative attitudes in classes yield better achievements among students. It then presents a simple model displaying that an insufficient degree of cooperation between classmates can decrease the overall achievement of the class, due to free riding incentives. A cooperative learning approach becomes desirable when a social cost exists due to the negative opinion of the classmates attached to a competitive behaviour. Empirical evidence supporting our model is found using the 2003 wave of PISA (OECD). A competitive learning approach has a positive individual return (higher in comprehensive educational systems), while the student performance increases with the average cooperative behaviour in the tracked educational systems.

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1. Introduction

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. Placing students in groups does not mean they will actually cooperate. There is considerable and disturbing evidence that students often do not behave pro-socially. 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)

The shared view of knowledge which develops in a learning community is voiced by 11 year olds reflecting on their learning: '*Even if you learn something perfectly, or are a pioneer in your area, all your work is useless if nobody else can understand you. You might as well have done no work at all. The point of learning is to share it with others. Lone learning is not enough.*' (quoted in Watkins 2005, p.59)

These two quotations summarise a pervasive debate among education scholars. Increasing empirical evidence suggests that group learning yields superior outcomes in terms of students' motivation and achievement.[1] Whatever teaching technique is adopted in a class (coupling of students for text revision, group investigation, "jigsaw" groups[2]), and irrespective of students' age or subject taught, most literature stresses the advantages of cooperative learning. According to the advocates of this approach, the main advantage of passing from a teacher-centred learning (namely "learning=being taught") to group learning is the appeal to individual intrinsic motivation for learning ("learning=individual sense-making" according to Watkins 2005).

Shachar and Fischer 2004 go back to Dewey's work to review the role of intrinsic ("..understood to be a person's interest in pursuing a goal without any palpable reward" – p.71) and extrinsic motivation in learning ("Extrinsic motivation in pursuit of a task is required or directed by external factors not on the basis of one's own wishes." – ibidem, p.71). They claim that group investigation is "...in fact 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 in the manner suggested by this method, as well as receiving and offering considerable support from, and assistance to, groupmates" (ibidem, p.73). In addition, group work requires caring for others, thus reinforcing the

[1] "Cooperative learning is an instructional strategy in which students work together in groups that are carefully designed to promote positive interdependence." (Abrami et al. 2000, p.177). See Abrami et al. 2000 and Watkins 2005 for review of the literature. Strijbos and Fischer 2007 discuss methodological issues in interdisciplinary research on collaborative learning.

[2] Zammuner 1995 reports evidence of comparing the text quality of individual writing to dyadic writing/revision in an experiment conducted among 4th graders; she finds higher quality improvement under individual writing and dyadic revision. She explains the result by observing that "...peer feedback might help writers increase their awareness of their own aims, of which strategies they have used to achieve their aims,..." (p.104). Shachar and Fischer 2004 consider the case of group investigation in 11th grade chemistry classes, showing a superior performance in test taking when compared to a control case of traditional teaching. 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. They do not find improvement in academic performance, but their study shows positive effects on intrinsic motivation, experience of competence (especially among low achievers) and activation of deeper level processing.

sense of community belonging.[3] Discussing with classmates involves reconciliation of multiple perspectives through the medium of dialogue, and this collaboration develops more sense of abstraction.

Finally, group activity allows for individualised attention for low achieving students, as well as providing an opportunity to high achievers to improve their understanding of the subject while exposing to the group. In whole-class instruction the pace of learning has to be identical across students, and this may reinforce competition among them in order to obtain symbolic rewards from the teacher (extrinsic motivation). In group learning all level students obtain a personalised motivation, provided that group composition does not mix extremes that are too far apart. More modern approaches indicate with the term of "learning communities" (namely "learning=constructing knowledge with others") the ultimate stage of cooperative learning.[4] However, students with different level of achievement differently appreciate group learning. Generally speaking, low achievers seem to gain more from group learning than high achievers. [5] In addition, high achievers are more inclined to gain recognition of their level of ability through competition in the class.[6]

Cooperative learning is not a spontaneous phenomenon, and requires some structuring from the teacher (Blumenfeld et al. 1996). As the forefront citation makes clear, groups work according to implicit or explicit norms that regulate individual contributions. The task assignment is the crucial point in the formation of each group, and some tasks (like problem solving and open ended problems) are more easily performed in group than others. Students need to be taught how to help others in group,[7] and individual accountability is essential to ensure generalised participation to cooperation.

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[3] "Students with higher sense of school membership report higher grades, and a more internal locus of control, the sense that success was more in their hands than in the hands of others" (Watkins 2005, p.50). Cowie and Berdondini 2001 show that cooperative group activity develops the ability to identify oneself in others' feelings, yielding a potential reduction of bystanding in front of bullying activities.

[4] "In a community of learners students use collaborative enquiry to address authentic questions they have generated, and their agency creates a range of effects: group productivity increases as students gain ownership, cognitive engagement increases as public dialogue centres on discussions of their own experiences, and students take responsibility for learning and teaching as they work in teams." (Watkins 2005, p.55).

[5] Hoek et al 1999 reports a mathematical reasoning test conducted among 7th grade students, where high achievers benefited more than low achievers (*differential effect*), but the same outcome was reversed in other types of tests. Low achievers seem also to benefit from additional attention from the teacher under group learning (*remedial effect*). Similarly, Shachar and Fischer 2004 report that low achievers gained more under group investigation, while high achievers lost less under the same modality.

[6] "The prevailing mores of the traditional classroom cultivate an individualistic, competitive orientation much to the disadvantage of average and slower learners, as well as inculcating the more gifted students with the competitive mores that seriously clash, at least in the short term, with the sudden introduction of a teaching-learning style that emphasizes peer cooperation, as occurred in the present experiment and elsewhere as well." (Shachar and Fischer 2004, p.83).

[7] In an experiment conducted with 9th graders, Gillies 2004 shows that that children in structured groups are more willing to work with others on the assigned tasks and they provide more elaborate help and assistance to each other than their peers in unstructured groups. Similarly, Hoek et al.1999 compare groups where the treated students were instructed on how to co-operate (giving more elaborated help and promoting equal participation), whereas the controls did not receive any training but were merely told to help each other. They find that students in the experimental program gained more than the students in the control program on two of the three tests.

Last, but not least, 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.[8]

As economists, however, we are tempted to stress more the extrinsic motivations, and to summarise the previous literature by noticing that learning in classes has strong similarities with the problem of public goods. Group learning (the public good) has positive externalities, since all students seem to improve in achievements. However, individual incentives favour free riding, and these incentives are increasing in student level of achievements. Group norms may reverse individual incentives, but they are strongly dependent on the environment.

In the sequel we expand this line of argument by proposing a model where each student can allocate her effort between two types of activity, cooperation or competition. Cooperation corresponds to group learning, and provides positive externalities to the entire class irrespective of individual contribution. Competition has a private return only, which is increasing in ability. As a consequence, under spontaneous ordering (corresponding to whole-class teaching) there is an excess of competition and limited cooperation. However, when group norms are modified (because a teacher may favour group learning), then these conclusions could be reversed.

These results are also relevant for labour market outcomes. Typically students enter the labour market bearing some signals (for example marks achieved at school) and an absolute level of competences (which can be ascertained for instance through interviews). Depending on the educational system at hand, students are likely to emphasize one aspect or the other. In schools where strong emphasis is placed on relative ranking (like the English ones), it is quite likely that individual efforts being concentrated in the production of good signals, possibly at the expenses of cooperating with others in acquiring general knowledge. On the contrary, when the focus is on school level acquisition of competences, cooperative attitudes are more likely to emerge.

This has implications on the overall performance of educational systems. In the second part of the paper, we take the theoretical predictions of the model to the data, using the PISA 2003 survey, where students self-declare their attitudes towards cooperation and competition in classes. We study the correlation between students' attitudes and performance, showing that there is an individual incentive to be competitive, but a class advantage in adopting cooperative strategies.

In Section 2 we present a model that frames cooperation and competition in learning, providing theoretical predictions. In Section 3 we provide some empirical evidence drawn from an international student survey, which contains information about student attitudes and performance. Section 4 concludes and discuss some implications for educational policy.

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[8] Despite common beliefs that Confucian heritage favours cooperation, Phuon-Mai et al. 2005 show that the same culture creates an obstacle to effective cooperation in learning.

2. Theoretical Framework

We assume that students attend school with the main goal of getting the highest possible marks, to be subsequently spent to find the best available job in the labour market. In every school marks are assigned considering the relative performance of the students. In other words, students participate in a tournament in which all the pupils of their school are involved.[9]

The chances of being confronted with students that are enrolled in other schools are very low, particularly within educational systems (like the Italian one) where students are evaluated by their teachers and not by means of standardized tests. Within such a framework we can safely assume that there are as many separate tournaments as schools. This does not preclude the possibility of countries with central exit examinations, which provide students with an assessment of their absolute knowledge.[10] But this typically occurs at the conclusion of their curricula, thus leaving students uninformed about their absolute performance during their schooling experience.

In most cases teachers' evaluation is not strictly related to the level of effective learning of the students. For example, in the entire sample of students interviewed by PISA-OECD in 2003, the correlation between test scores and marks in mathematics is just equal to a scanty 0.17, which is the weighted average of country level correlation ranging from –0.48 of the Czech Republic to +0.70 of Portugal.[11] Notice that if valuations are consistent across schools a positive correlation should emerge, since they mainly internalize the level of knowledge. In contrast, absence of correlation points toward every school running a separate tournament in which only relative evaluation matters. A negative correlation can be rationalized for instance with grade inflation not uniformly distributed in the country (like in Italy, see Cipollone and Sestito 2007). Nevertheless, marking students performance is one of the main task of teachers worldwide, and therefore we take it as a standard activity carried out in schools (up to the point that many authors speak of "grade inflation" – see for example Chan et al 2005, Marks 2002 and Correa 2001).

The relative performance within one's school is a useful signal of students' ability, which certainly affects their likelihood of finding a suitable job. However, such a signal is imperfect, and the employers adopt other devices, like interviews, to compare the candidates who often come from different schools. There are two components that are salient in this framework. The first is a relative component, i.e. the knowledge acquired in comparison with the students coming from the same school, as certified by the final grade that summarizes the ranking between the pupils who attended that school. The second is an absolute component, which instead is not captured by the relative ranking within each school, which has to be evaluated in order to compare students who come from different schools.

[9] For the sake of simplicity we do not separate students within each school according to their marks.
[10] Wößmann 2005 has shown that countries with centralised examination system exhibit better student performance.
[11] However the grading policy of the teacher has been proved effective as an incentive device for effective learning. See Betts 1998.

We assume that students are myopic and, when at school, they only care about being in the highest possible position in the ladder, while they disregard the long run consequences of their current choices concerning the absolute level of knowledge. In fact, many studies in education, psychology and economics document how children may be more clearly motivated by short-run gratification rather than less tangible long-run rewards (see Chelonis, Flake, Baldwin, Blake and Paule 2004, Harbaugh and Krause 1998, Bettinger and Slonim 2006).

2.1 The Production of Knowledge

We consider that each agent decides her optimal amount of knowledge allocating time between leisure on the one hand and production of knowledge on the other hand.[12] The simplest way to model this decision is to consider that learning has an opportunity cost which is identical among students, and for simplicity described by a quadratic disutility function.

We assume that *private knowledge* is produced through individual learning. This requires not sharing the knowledge acquisition with classmates, possibly to be recognised as better than others in class. Symmetrically, we assume that *public knowledge* is achieved through learning in a group, which necessarily requires sharing knowledge with others. An example can be described by fluency in language. Private knowledge occurs whenever a student learns the meaning of a specific word on her own. We speak of private knowledge even if the word is known by a group of students, or by the whole class, provided that every student has learned the word without interacting with the classmates. Public knowledge instead corresponds to the case where an entire class can use a specific word thanks to group interaction. Another example is given by homeworks: the time students spend solving the assignments individually enters the definition of effort devoted to the production of private knowledge. In contrast, if students works in groups what they learn by solving the homeworks is classified as public knowledge.

The crucial issue in our model is how students' time is allocated between individual learning (production of private knowledge) and group learning (production of public knowledge). We face here the usual free riding problem: everybody has the incentive of allocating the maximum amount of time to the acquisition of private knowledge, while hoping that at the same time all the other fellow students invest enough time in acquiring public knowledge. Using one of the aforementioned examples, this corresponds to a student participating in group working only to get the solutions of the homeworks costly elaborated by his classmates, and then spending most of his time studying alone in order to get higher marks. The underlying reason is that the time devoted to group learning has a small individual return, since it is diluted among all the participants. The higher the number of students, the lower the individual return on time spent producing public knowledge. In the limit situation in which there is a continuum of agents and the individual contribution is negligible the optimal

[12] When talking about the allocation of time we refer to the time out of the class (e.g. homeworks), or in any case to the time in which students are not told by the teacher what to do.

contribution to the production of public knowledge is equal to zero (purely competitive outcome).

The simplest way of formalizing such a framework is the following[13]

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

where p_i is the time devoted to individual learning by student i, s_i is the time devoted to learning in a group, α_i is individual ability and $\tilde{s}$ is public knowledge, defined as

$$\tilde{s} = \frac{2}{n}\sum_{i=1}^{n} \alpha_i s_i \ . \tag{2}$$

Notice that the incentives of acquiring knowledge are increasing in individual ability α_i, which is somehow distributed between students. Notice also that the public knowledge amounts to twice the average contribution. Using the average only would simply imply a redistribution of knowledge from the best to the worst students. For group learning to have a fostering effect on total knowledge it is necessary that the output is higher than the sum of the inputs, so we choose twice the average for the sake of simplicity.

From the first order conditions the following optimal choices emerge:

$$\arg\max_{p_i}[U_i] = p_i^* = \alpha_i \tag{3}$$

$$\arg\max_{s_i}[U_i] = s_i^* = \frac{2\alpha_i}{n} \tag{4}$$

with the contribution to public knowledge going towards zero when the number of students is sufficiently large.

In both cases learning turns out to be an increasing function of ability, and every student spends a larger fraction of her time producing knowledge privately, i.e. learning individually, provided that *n>2*. Also the contribution to public knowledge is increasing in ability, although less than private knowledge. Good students are those who contribute more, and bad students are those who benefits more from public

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[13] Similar results are obtained by means of a Cobb-Douglas utility function, where the coefficients are a function of ability, subject to an explicit time constraint.
Notice that in the specification adopted above, it makes a significant difference whether the disutility of learning is modelled separately for private and public knowledge, or instead considering the sum of the time devoted to both tasks. If a student cares only about the total time spent studying, but she is indifferent concerning its allocation between cooperative or competitive learning, the outcome will be a corner solution where she spends her time only on the task yielding the highest return at the margin. In contrast, modelling the two costs separately allows internal solutions to emerge, because it implies that the students prefer to diversify between the two activities, and this is our preferred modelling strategy.

knowledge whenever its amount is positive (since they obtain more public knowledge than what they contribute to).

The first testable implication of the model is therefore that the effort exerted in the production of both private and public knowledge is increasing in ability, the former more than the latter.

The optimal amount devoted to the production of private knowledge, would be even higher when relative evaluation in class is explicitly considered, because at the margin also the density of knowledge (intuitively, the fraction of students that can be overcome increasing one's effort by a small amount) affects the choice, and this makes competition more rewarding.[14]

So far no reason has been provided for the students to adopt a cooperative learning approach, defined as devoting a larger amount of time to the production of public knowledge:

$$s_i^* > p_i^* . \tag{5}$$

Why could we expect to observe a degree of cooperation larger than that implied by self-interest? The first possibility is to assume that (some) students are sufficiently sophisticated to correctly anticipate that future competition in the labour market is based on total knowledge. However, this possibility is undermined by the fact that the presence of some myopic classmates lowers also one's individual return. In other words, even though the best students care about their total knowledge, there is not much they can do as long as most of their classmates are myopic and provide a suboptimal contribution to public knowledge. The second possibility is to assume that students enjoy cooperative learning because it is one of the opportunities of interacting with their classmates. Moreover, a selfish behaviour in terms of learning is likely to be punished in terms of exclusion from the social activity inside and outside the class.

We model the fact that students care about the opinion of their classmates transforming our model in a psychological game in which opponents' beliefs enter the utility function:

$$U_i = \alpha_i p_i + \tilde{s} - \frac{1}{2}(p_i)^2 - \frac{1}{2}(s_i)^2 - \mu(p_i - s_i). \tag{6}$$

The last term summarizes that a cooperative learning approach $s_i > p_i$ generates a good opinion from the classmates, and therefore implies a positive utility, while the opposite holds when the choice is instead a competitive learning approach $p_i > s_i$.

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[14] This amounts to add in (1) a term like $\beta\int_0^{p_i} f(p(\alpha))d\alpha$, summarizing that the student experiences a higher utility proportional to the fraction of fellows with a lower level of private learning, since public knowledge is the same for everybody. Of course, the magnitude of such an effect crucially depends on the distribution of individual ability.

If students do not care about the relative evaluation but only about the level of knowledge, the optimal amounts becomes respectively:

$$p_i^* = \alpha_i - \mu \tag{7}$$

$$s_i^* = \frac{2\alpha_i}{n} + \mu . \tag{8}$$

The opinion of the classmates, modelled in this simple way, has the effect of shifting time from competitive to cooperative learning without changing the overall amount of time devoted to studying. Both p_i* and s_i* are still increasing in ability, the former (again) more than the latter. In other words, the incentive to cooperate does not change much according to individual ability, and does not change at all when n is sufficiently large. On the other hand, production of private knowledge has an increasing return in ability. Therefore, there is a threshold of ability which divides the students characterized by a competitive learning approach from those characterized by a cooperative learning approach that is obtained equating equations (7) and (8).

Competitive learning occurs for all students characterised by a level of ability

$$\alpha_i > \frac{n}{n-2} 2\mu . \tag{9}$$

The second testable implication is therefore that we expect a positive correlation between ability and propensity to adopt a *competitive learning*.

Now let us see what happens to the amount of knowledge of the whole class, as measured for instance by a standardized test that mimics the outcome of job market interviews that involve pupils from different schools. We define the total knowledge K of a class simply as the sum of the total knowledge of each student:

$$K = \sum_{i=1}^{n} K_i \tag{10}$$

where $K_i = \alpha_i p_i^* + \tilde{s}$, given that total knowledge is the outcome of individual learning ($\alpha_i p_i$) and shared knowledge ($\tilde{s}$).
Note that public knowledge affects the outcome of every student, irrespective both of individual participation to group activities (s_i) and of individual ability, provided that n is not too small. In other words, the public knowledge $\tilde{s}$ is counted n times when computing the score of the class.

As long as the public knowledge exceeds the sum of the inputs, the total knowledge of a class turns out to be increasing in the degree of cooperation within the class by construction. In fact, when class size is sufficiently large and when reputation about being a cooperative person is irrelevant, i.e. μ=0, a purely competitive outcome emerges with individual contribution to public knowledge tending towards zero, and therefore also $\tilde{s} = 0$. The total knowledge, assuming that ability is uniformly distributed between zero and one, $\alpha_i \approx U[0,1]$, is simply

$$K = \int_0^1 k_i d\alpha = \int_0^1 \alpha p_i d\alpha = \int_0^1 \alpha^2 d\alpha = \left[\frac{1}{3}\alpha^3\right]_0^1 = \frac{1}{3}. \tag{11}$$

When the opinion of the classmates enters students' utility function, affecting their propensity to cooperate, the picture changes sharply, since public knowledge becomes positive.

$$\tilde{s} = 2\int_0^1 \alpha s(\alpha) d\alpha = 2\int_0^1 \alpha\mu d\alpha = \mu \tag{12}$$

applying what found in equation (4) under the assumption of a continuum of agents. Similarly, total knowledge increases:

$$\begin{aligned} K &= \int_0^1 (\alpha p_i + \tilde{s}) d\alpha = \int_0^1 [\alpha(\alpha - \mu) + \mu] d\alpha = \\ &= \left[\frac{1}{3}\alpha^3\right]_0^1 - \mu\left[\frac{1}{2}\alpha^2\right]_0^1 + \mu[\alpha]_0^1 = \frac{1}{3} + \frac{\mu}{2} \end{aligned} \tag{13}$$

The same results hold qualitatively when the number of students is finite. When the incentive to cooperate is based on the individual return only, the public knowledge coming from cooperative learning is:

$$\tilde{s} = \frac{2}{n}\sum_{i=1}^{n} \alpha_i s_i = \frac{2}{n}\sum_{i=1}^{n} \frac{2\alpha_i^2}{n} = \frac{4}{n^2}\sum_{i=1}^{n} \alpha_i^2 \tag{14}$$

and total knowledge therefore:

$$K = \sum_{i=1}^{n} (\alpha_i p_i + \tilde{s}) = \sum_{i=1}^{n} \alpha_i^2 + n\tilde{s} = \left(\frac{n+4}{n}\right)\sum_{i=1}^{n} \alpha_i^2 \tag{15}$$

When the opinion of the classmates enters students' utility function, public knowledge obviously increases and becomes:

$$\tilde{s} = \frac{2}{n}\sum_{i=1}^{n} \alpha_i s_i = \frac{2}{n}\sum_{i=1}^{n} \left(\frac{2\alpha_i^2}{n} + \alpha_i\mu\right) = \frac{4}{n^2}\sum_{i=1}^{n} \alpha_i^2 + 2\mu\overline{\alpha} \tag{16}$$

while total knowledge is also greater and equal to:

$$\begin{aligned} K &= \sum_{i=1}^{n} (\alpha_i p_i + \tilde{s}) = \sum_{i=1}^{n} [\alpha_i(\alpha_i - \mu)] + n\tilde{s} = \\ &= \sum_{i=1}^{n} \alpha_i^2 - n\mu\overline{\alpha} + \frac{4}{n}\sum_{i=1}^{n} \alpha_i^2 + 2n\mu\overline{\alpha} = \left(\frac{n+4}{n}\right)\sum_{i=1}^{n} \alpha_i^2 + n\mu\overline{\alpha} \end{aligned} \tag{17}$$

The third testable implication is therefore that the stronger the social preferences for cooperation, the larger the number of students who adopt a cooperative learning approach, the larger the amount of public knowledge and therefore the larger the amount of total knowledge. In other words, total knowledge should be increasing in the reallocation of learning effort from individual learning to group learning ($\Delta\mu > 0$, see equation (9)).

What can affect the preferences for cooperation? In more homogeneous environments, the opinion of classmates is likely to be more relevant. The simplest way to model such a feature is to make social preferences a (decreasing) function of students heterogeneity $\mu(\sigma_{\alpha}^{2})$. This of course requires relaxing the assumption that $\alpha_i \approx U[0,1]$ in such a way that the variance in school composition may change across schools. As a consequence, tracked educational systems, characterized by a more homogeneous body of students (since they are often sorted by ability into tracks), should display a relatively higher degree of cooperation and a lower degree of competition.

Moreover, if we believe that group working is more productive when involving extremes that are not too far apart, also equation (9) should be generalized making public knowledge a decreasing function of students heterogeneity. If this is the case, tracked educational systems should also display a higher return to aggregate cooperative behaviour.

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In a nutshell what happens is that choosing the optimal amount of learning based on individual incentives only might be inefficient. In fact, the investment in group learning is inefficiently low because of the free riding problem. The presence of strong preferences for cooperation within the class may overcome at least in part such inefficiency.

Summarizing, some testable implications can be derived from the previous model:

- ✓ the effort exerted in the production of both private and public knowledge is increasing in ability;
- ✓ the best students should be characterized by a competitive learning approach, while the opposite holds for the worst students;
- ✓ students' knowledge should increase with the individual competitive behaviour and with the average cooperative behaviour (while no direct effect should be associated to the private cooperative behaviour and to the average competitive behaviour);
- ✓ 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.

3. Empirical Evidence

The OECD's Programme for International Student Assessment (PISA) surveys are designed to collect information on real-life competences from 15-year-old students, on a comparable cross-country base.[15] These surveys are conducted every three years, and cover reading, mathematical and scientific literacy, and problem solving, with a dominant area in each survey. The 2003 survey 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 information and family background, to characteristics of the school and of the education system.

In the PISA questionnaire there are also some questions concerning students' learning approach. Two sets of questions concern their preference for competitive learning[16] and cooperative learning[17] respectively, which are not mutually exclusive. In fact, it may well be that a student want to outperform their classmates, at the same time having preferences for cooperative learning. These aptitude information has been summarised by the OECD researchers (using principal component analysis) into two variables (COOPLRN and COMPLRN).[18]

How can we use the data from PISA survey to test the prediction of the model outlined in the previous section? Several assumptions are necessary in order to compare the model with the data. In our model, individual knowledge is function of endowments (that we termed ability) and behaviour (in terms of individual learning and group learning). Unfortunately, the PISA dataset does not contain any reliable proxy for

[15] "PISA seeks to measure how well young adults, at age 15 and therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies. The assessment is forward-looking, focusing on young people's ability to use their knowledge and skills to meet real-life challenges, rather than merely on the extent to which they have mastered a specific school curriculum." (PISA 2004, p.20).

[16] 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.

[17] 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.

[18] Wallace et al. 2002 show that individual understanding of student survey statements is related to the level of student achievement, and is also variable over time: "There is increasing evidence to suggest that members of a classroom do not share the same learning environment; neither do they share the same meanings for the constructs used to measure the environment." (ibidem, p.134). However, in the PISA case the statement refers to individual attitude and not to class perception, and therefore we feel less troubled in using it.

unobservable ability. However, if we take a sufficiently broad definition of ability as anything that contributes to the child learning and that is possessed by the child before entering the school, then all family related information can be considered as proxy for the (observable) component of ability. The unobservable component of ability will end up in the residual of any regression of students' test score on family background and school resources.

We know from existing studies on student performance (see for example Wößmann 2003 or Ammermüller 2005) that individual test scores are positively correlated with family background (parental education, index of parental socio-economic status, number of books at home, internet connected computer at home, proxy for durables possession), with some proxy for school resources (instructional time, number of computer, but not class size) and with some institutional indicators (existence of central exit examination systems, source of funding).

We use the student test scores as measure of the knowledge possessed by each student.[19] We take students attitudes expressed with respect to competition and cooperation with other students as proxies for the allocation of their effort in the direction of individual learning (if they express stronger preference for individual learning) or in the direction of group learning (in case they express an alternative preference for cooperating with others).

PISA surveyed students by schools and not by classes, with an average of 33 students tested per school. After excluding data from schools with less than ten students, we take school averages as the best available proxy of class averages.

Under this set of assumptions, let us confront the predictions of our model with the empirical evidence in the data. From the original dataset (276.165 observations), we have excluded students who were not enrolled in the modal grade (98.963 cases excluded), because they could represent distorted subsamples (either in terms of ability, for those students who were repeating one school grade, or in terms of attitudes toward cooperating with others, for drop out students who were facing rather different peers). We have also dropped countries where the distribution of test scores was too much dissimilar from the remaining of the sample and/or there were too many missing values in family background information (47,313 cases excluded).[20] By excluding individuals in schools with less than 10 students and with missing information on some of the covariates we are left with 110,711 observations covering 27 countries (descriptive statistics are summarized in table 1, while table 2 displays the breakdown by country). For each student in the sample we compute the average attitude in the school towards competitive and cooperative learning, excluding his/her own opinion.

Let us first consider attitudes and ability. The theoretical model predicts that both effort exerted producing individual knowledge and time devoted to cooperation should

[19] Actually, PISA dataset contains five plausible values for each student, since each student was tested on a subsample of questions. We use the average across the five plausible values.
[20] The countries excluded are Brazil, Greece, Indonesia, Latvia, Liechtenstein, Luxembourg, Macao (China), Mexico, New Zealand, Portugal, Slovakia, Thailand, Tunisia, Turkey, Uruguay, Yugoslavia.

increase with ability, therefore displaying a positive correlation. The sample correlation between the competitive and cooperative attitude is 0.27 [71.8].

The model has been set up assuming that a person exhibits either a competitive learning approach (whenever $p_i^* > s_i^*$) or a cooperative one (in the opposite case), and that she would be more likely to adopt the former behaviour the higher her ability. However, questions concerning students' learning approach are not mutually exclusive in the dataset. A student can display at the same time both a stronger willingness to outperform the others and a higher propensity to cooperate than another student. For this reason we have tried to capture the prevailing attitude of the students by taking the difference between the two opinions, on the assumption that a competitive learner is more likely to express stronger support when considering a competitive behaviour instead of a cooperative one.

In table 3 we have reported the correlation of this measure (COMPLRN minus COOPLRN) with two alternative definitions of family background. In column 1 we have considered the highest education and occupational prestige in the parent couple; in column 2 we have replaced these two attributes with an aggregate measure, which also incorporate information related to household possession (variable ESCS - index of Economic, Social and Cultural Status). In both cases a competitive approach exhibits positive correlation with all these measures of family background, which are a component of overall student ability, in line with the prediction of the model.

We also find evidence of the fact that girls have less competitive and more cooperative attitudes than boys. It is also interesting to notice that there are significant cross-country variations in this attitude, as captured by the estimated country fixed effects, which are also reported in graphical form in figure 1. Cooperative attitudes seem prevalent among Nordic countries (Sweden being an exception), while competitive attitudes dominate in Anglo-Saxon and Eastern Asian countries.

We now consider the correlation between acquired knowledge, individual ability and competitive/cooperative attitudes. In table 4 we report OLS estimates of the correlation of students test scores, measures of family background and available measure of attitudes. Country fixed effects are included; robust standard errors are clustered by school and country.

In column 1 we consider the individual attitudes toward competition/cooperation, in column 2 we consider the school averages (computed excluding his/her own attitude) and finally in column 3 we include both individual and school-level measures. We are not surprised by finding that the test score displays a positive association with alternative measures of family background (including parental education, parental occupational prestige, computer facilities and books at home, possession of durables). We also include a proxy for individual effort, which is given by the amount of hours per week spent on "Homework or other study set by your teachers". Thus the individual level of knowledge is positively associated with (the observable components of) ability and effort. When we consider the attitudes, we find that best performing students are also those who express stronger support for individual learning, while those more in favour of group activity are also those with lower performance. As a consequence, a competitive attitude is positively associated to individual acquisition of knowledge, while cooperative attitude shows a negative correlation with it.[21]

More surprising are the correlations with school-level attitudes reported in column 2 of table 4. Here we observe a reversal of signs. Other things constant, students in schools where competitive attitudes are prevalent obtain lower knowledge, while the opposite situation is observed when cooperative attitudes towards learning occur. When we combine both individual and collective attitudes (column 3), results are confirmed. Results therefore remind us a hawk-dove game, where it pays to diversify only in one direction: it is convenient to be a hawk in a world of doves, but not vice versa. Here we find that it pays being competitive while all the others are cooperative, because one obtains both the benefit of the private good (individual learning) and the public good (the public knowledge). On the contrary, expressing cooperative attitudes when all classmates share an opposite preference seems to be associated to the worst of the possible worlds.

This situation is quite consistent with the results of our theoretical model, where individual knowledge increases with the individual competitive behaviour and with the average cooperative behaviour. However, the model does not consider negative externalities from the average competitive behaviour (which could be rationalized by means of sabotage), and it does not predict a negative impact of individual cooperative behaviour.

In table we introduce additional features of the national educational system. We classify countries as “comprehensive” or “tracked” on the basis of whether students were attending one or more secondary school types (see footnote of table 1). We then interact this dummy variable with individual and collective attitudes, finding that individual returns (in terms of knowledge acquisition) are reduced in tracked systems, whereas the penalty associated to cooperative behaviour vanishes there. When looking at school level, we observe that average competitive attitude remains associated to a negative premium in the comprehensive systems, while there is huge reward to the prevalence of cooperative attitudes in tracked educational systems only. If we consider that tracked educational systems are more homogeneous in terms of student abilities,[22] our results suggest that cooperation is more viable with classmates that are more similar among each other, in line with the prediction of the model.[23]

Our model is quite in line with this evidence. If we remember that the incentives to adopt individual or group learning were parameterised on μ (measuring the utility impact of classmates opinion about being pro-cooperation), we do expect that in more homogeneous environments social control is more intensive, and students care more

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[21] Notice that there is no causal implication in these (spurious) correlations, because in accordance with our model both variables are correlated with the unobservable component of individual ability.

[22] In tracked systems, the within-schools inequality in student test scores is lower, while the between-schools inequality is higher, in line with the prediction of the model.

[23] Once again, we abstain from reading any causal relationship in these correlations. For example Hanushek and Wößmann 2006 claim that tracking has a (causal) negative impact on average student performance, and a positive impact of their dispersion. If student performance would be associated to attitudes (better students choosing competitive attitudes and worst student preferring cooperative ones), we would replicate our empirical evidence, with the causal relationship passing through performance.

about the perception of their behaviour by other class-mates. If tracked educational systems can be thought as characterised by higher μ, then we should observe the prevalence of less competitive attitudes and more cooperative ones. As a consequence, total knowledge should be higher in tracked systems because the public component of knowledge is higher. In the data, we find partially consistent results. First of all, in tracked educational systems we find that returns to individual learning are lower, while returns to cooperative learning are nil. From the theoretical model we do expect less of the former activity and more of the latter, but no variation in individual incentives. As far as aggregate behaviours are concerned, we know from other studies (Hanushek and Wößmann 2006) that a tracked educational system has a negative impact on average students' performance. However, we are not testing the direct impact of tracking on student test scores (which is also captured by the country fixed effects), but the impact of its interaction with the average cooperative attitude. We find that test scores are higher when average cooperation is higher, but in tracked systems only. In our view this reinforces our line of argument: tracked systems should be associated to a lower performance, but when cooperative attitudes emerge in these countries, they can outperform comprehensive educational systems. This is also consistent with the claim of the educationalists that group learning enhances intrinsic motivations provided that students are not too different among each other.

Finally we wanted to test whether these attitudes had a different impact at different levels of student's knowledge (which is correlated to unobservable components of ability once we control for family background). In table 5 we report quantile regressions at three points of the distribution of test scores (25^{th}, 50^{th} and 75^{th} percentile). Standard errors are obtained from bootstrapping (100 replications). The relevant coefficients (incorporating the effect of interactions in the case of tracked systems) are also plotted in figure 2. When considering comprehensive educational systems, we observe that competitive attitudes are increasingly associated with performance, while the opposite applies to cooperative attitudes. Thus best students are more inclined to adopt individual learning, while worst student have lower disincentive when preferring cooperative learning. When considering tracked educational systems, incentives to competitive behaviour are halved but remain increasing in student performance, while disincentives for cooperative attitudes disappear independently of the student level of knowledge. As far as the school environment is concerned, average competitive attitudes are penalising for all students' level of ability, irrespectively of the type of educational system in place. On the contrary, aggregate cooperative attitudes represent an opportunity (increasing in student brightness) only in tracked educational systems.

4. Conclusions

In the present paper we show another occurrence of "failure of composition". A theoretical model displays that private incentives do not necessarily coincide with public ones. In a public good game (where social knowledge represents the public good at hand) this leads to a suboptimal provision of cooperation, due to free riding incentives. The free riding problem may be attenuated whenever reputation among peers is relevant for the individual. This is obtained by means of a positive utility impact of cooperative behaviour via classmates opinion, then showing that total knowledge increases in association with more time allocated to the production of public knowledge.

We then take these implications to the data, using a survey conducted in 2003 by the OECD-PISA consortium. In this surveys students express their preferences towards competitive ("*I do my best work in mathematics when I try to do better than others*") or cooperative ("*I do my best work in mathematics when I work with other students*") learning. We study the correlation between these attitudes, family background and student performance in tests. We show that competitive attitudes are increasing in the observable component of ability (parental education and occupation). In addition, even when controlling for additional aspects of family background, we show that student test scores (a reasonable proxy for knowledge) are positively correlated with competitive attitudes and negatively correlated with cooperative ones. However, the situation is reverted when we take into account the peers' attitude: learning in a competitive environment is detrimental to knowledge, while a cooperative environment favour individual performance.

We also analyse whether these conclusions are strengthened in more homogenous environments, as represented by tracked educational systems. We found that tracked systems seem to foster cooperation possibly because of a stricter monitoring of individual competitive behaviours, or simply because students care more about the opinions of the classmates the more similar they are among each other. Finally we have investigated whether these average returns tend to vary according to the student level of performance in test scores. We find that individual incentives to compete in comprehensive school systems as well as to cooperate in tracked schools are both increasing in student performance.

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Tables and graphs

Table 1 - Descriptive statistics – PISA 2003

Variable	Obs	Mean	Std. Dev.	Min	Max
Test score in mathematics	110711	530.116	84.584	192.740	848.995
Female	110711	0.517	0.500	0.000	1.000
Age	110711	15.799	0.288	15.170	16.420
Highest parental occupational status	110711	50.411	16.098	16.000	90.000
Highest parental education in years of schooling	110711	13.362	2.854	0.000	17.000
Computer facilities at home	110711	0.234	0.893	-1.676	1.051
Index of home possessions	110711	0.178	0.920	-3.787	1.940
Hours All homework	110711	6.236	5.614	0.000	30.000
How many books at home	110711	3.705	1.358	1.000	6.000
Competitive learning	110711	-0.035	0.967	-2.844	2.450
Co-operative learning	110711	-0.015	0.968	-3.134	2.742
Tracking*	110711	0.480	0.500	0.000	1.000

* Countries classified as tracked according to the distribution of the type of secondary school attended (variable PROGN): Austria, Belgium, Czech Republic, Denmark, France, Germany, Hong Kong (China), Hungary, Ireland, Italy, Japan, Korea, Netherlands, Russian Federation, Spain

Table 2 – Countries included in the analysis – PISA 2003

Country ID	Freq.	Percent	Cum.
Australia	7553	6.82	6.82
Austria	2062	1.86	8.68
Belgium	5144	4.65	13.33
Canada	18134	16.38	29.71
Czech Republic	2884	2.60	32.32
Denmark	3008	2.72	35.03
Finland	4704	4.25	39.28
France	2292	2.07	41.35
Germany	2178	1.97	43.32
Hong Kong (China)	2383	2.15	45.47
Hungary	2480	2.24	47.71
Iceland	2918	2.64	50.35
Ireland	2048	1.85	52.20
Italy	8712	7.87	60.07
Japan	3737	3.38	63.44
Korea	4515	4.08	67.52
Netherlands	1415	1.28	68.80
Norway	3388	3.06	71.86
Poland	4038	3.65	75.51
Russian Federation	3439	3.11	78.61
Spain	6886	6.22	84.83
Sweden	3829	3.46	88.29
Switzerland	4967	4.49	92.78
United Kingdom	5273	4.76	97.54
United States	2724	2.46	100.00
Total	110711	100	

Table 3 – Competitive attitude and family background – PISA 2003

	1	2
	complrn-cooplrn	complrn-cooplrn
female	-0.289	-0.29
	[-0.125]***	[-0.125]***
Highest parental occupational status	0.002	
	[0.023]**	
Highest parental education in years of schooling	0.007	
	[0.017]*	
Index of Socio-Economic and Cultural Status		0.05
		[0.038]***
Australia	0.179	0.347
	[0.039]**	[0.076]***
Austria	-0.363	-0.196
	[-0.042]***	[-0.023]***
Belgium	-0.356	-0.188
	[-0.065]***	[-0.034]***
Canada	-0.026	0.142
	[-0.008]	[0.045]***
Czech Republic	-0.12	0.051
	[-0.017]	[0.007]***
Denmark	-0.324	-0.151
	[-0.046]***	[-0.021]***
Finland	-0.207	-0.037
	[-0.036]**	[-0.007]**
France	-0.2	-0.034
	[-0.025]**	[-0.004]**
Germany	-0.07	0.095
	[-0.008]	[0.011]***
Hong Kong (China)	0.11	0.284
	[0.014]*	[0.036]***
Hungary	-0.367	-0.192
	[-0.047]***	[-0.025]***
Iceland	0.515	0.672
	[0.071]***	[0.093]***
Ireland	0.164	0.337
	[0.019]**	[0.039]***
Italy	-0.187	-0.017
	[-0.043]**	[-0.004]
Japan	0.21	0.394
	[0.033]**	[0.062]***
Korea	0.68	0.85
	[0.116]***	[0.145]***
Netherlands	-0.357	-0.185
	[-0.035]***	[-0.018]***
Norway	-0.383	-0.22
	[-0.057]***	[-0.033]***
Poland	-0.03	0.143
	[-0.005]	[0.023]***
Russian Federation	-0.044	0.136
	[-0.007]	[0.020]***
Spain	-0.066	0.099
	[-0.014]	[0.021]***
Sweden	0.125	0.291
	[0.020]	[0.046]***
Switzerland	-0.526	-0.354
	[-0.094]***	[-0.063]***
United Kingdom	0.036	0.205
	[0.007]	[0.038]***
United States	0.076	0.246
	[0.010]	[0.033]***
Observations	110711	110711
R-squared	0.07	0.07
Log likelihood	-169246.99	-169234.92

Robust normalized beta coefficients in brackets - errors clustered by country

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4 – Performance in math tests – PISA 2003

	1 individual attitude	2 school attitude	3 individual +school attitude	4 individual +school attitude (x tracking)
Female	-15.815	-18.732	-16.229	-16.349
	[24.49]***	[29.62]***	[25.22]***	[25.53]***
Age of student	3.142	2.96	3.069	3.015
	[3.46]***	[3.25]***	[3.38]***	[3.33]***
Highest parental occupational status	0.755	0.759	0.757	0.751
	[40.42]***	[40.41]***	[40.51]***	[40.36]***
Highest parental education in years of schooling	1.463	1.489	1.464	1.436
	[13.57]***	[13.76]***	[13.58]***	[13.36]***
Computer facilities at home	6.598	6.608	6.547	6.542
	[15.68]***	[15.74]***	[15.59]***	[15.59]***
Index of home possessions	6.533	7.008	6.616	6.617
	[14.55]***	[15.53]***	[14.72]***	[14.80]***
Hours All homework	1.398	1.561	1.413	1.388
	[20.94]***	[23.99]***	[21.52]***	[21.25]***
How many books at home	12.293	12.215	12.225	12.177
	[51.14]***	[50.89]***	[51.01]***	[51.02]***
Competitive learning	8.586		8.859	10.573
	[27.05]***		[31.20]***	[27.41]***
Co-operative learning	-3.844		-4.032	-6.857
	[13.53]***		[15.21]***	[19.60]***
school average competitive attitude		-4.116	-8.237	-10.115
		[1.81]*	[3.66]***	[3.57]***
school average cooperative attitude		6.543	8.051	-1.269
		[2.78]***	[3.46]***	[0.51]
competitive attitude x tracking				-3.803
				[7.06]***
cooperative attitude x tracking				6.414
				[12.32]***
school average competitive x tracking				1.581
				[0.36]
school average cooperative x tracking				21.333
				[4.38]***
Observations	110711	110711	110711	110711
R-squared	0.24	0.23	0.24	0.24
Log likelihood	-633129.61	-633707.49	-633074.67	-632904.98

Robust t statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%
robust errors or clustered by country+school – country controls included

Table 5 – Performance in math tests – quantile regressions – PISA 2003

	1 q25	2 q50	3 q75
Female	-13.349	-17.598	-20.757
	[20.56]***	[30.27]***	[32.66]***
Age of student	0.076	3.037	3.796
	[0.07]	[3.13]***	[3.28]***
Highest parental occupational status	0.794	0.781	0.716
	[36.76]***	[38.75]***	[34.36]***
Highest parental education in years of schooling	1.456	1.473	1.595
	[11.35]***	[10.25]***	[11.97]***
Computer facilities at home	6.633	6.536	6.781
	[14.38]***	[14.35]***	[12.39]***
Index of home possessions	8.111	6.88	4.217
	[15.33]***	[14.25]***	[7.18]***
Hours All homework	1.662	1.429	1.064
	[27.89]***	[24.16]***	[18.57]***
How many books at home	11.692	12.794	14.05
	[38.45]***	[45.53]***	[41.35]***
competitive learning	8.053	10.886	12.337
	[18.62]***	[26.30]***	[30.52]***
competitive attitude x tracking	-2.539	-4.842	-5.757
	[4.18]***	[6.96]***	[7.61]***
co-operative learning	-5.067	-6.083	-6.303
	[11.11]***	[15.84]***	[15.82]***
cooperative attitude x tracking	4.933	6.553	6.038
	[6.66]***	[9.06]***	[7.72]***
school average competitive attitude	-10.008	-11.219	-9.393
	[5.93]***	[8.45]***	[5.91]***
school average competitive x tracking	0.227	2.623	3.192
	[0.09]	[0.94]	[1.29]
school average cooperative attitude	1.038	1.517	-0.905
	[0.60]	[0.93]	[0.52]
school average cooperative x tracking	19.133	20.861	23.87
	[5.54]***	[6.10]***	7.95]***
Observations		110687	
R-squared	0.1312	0.1389	0.1404

Bootstrap t statistics in brackets (100 replications)
* significant at 10%; ** significant at 5%; *** significant at 1%
Country controls included

Figure 1 – Country fixed effect when predicting (competitive-cooperative) attitude – PISA 2003

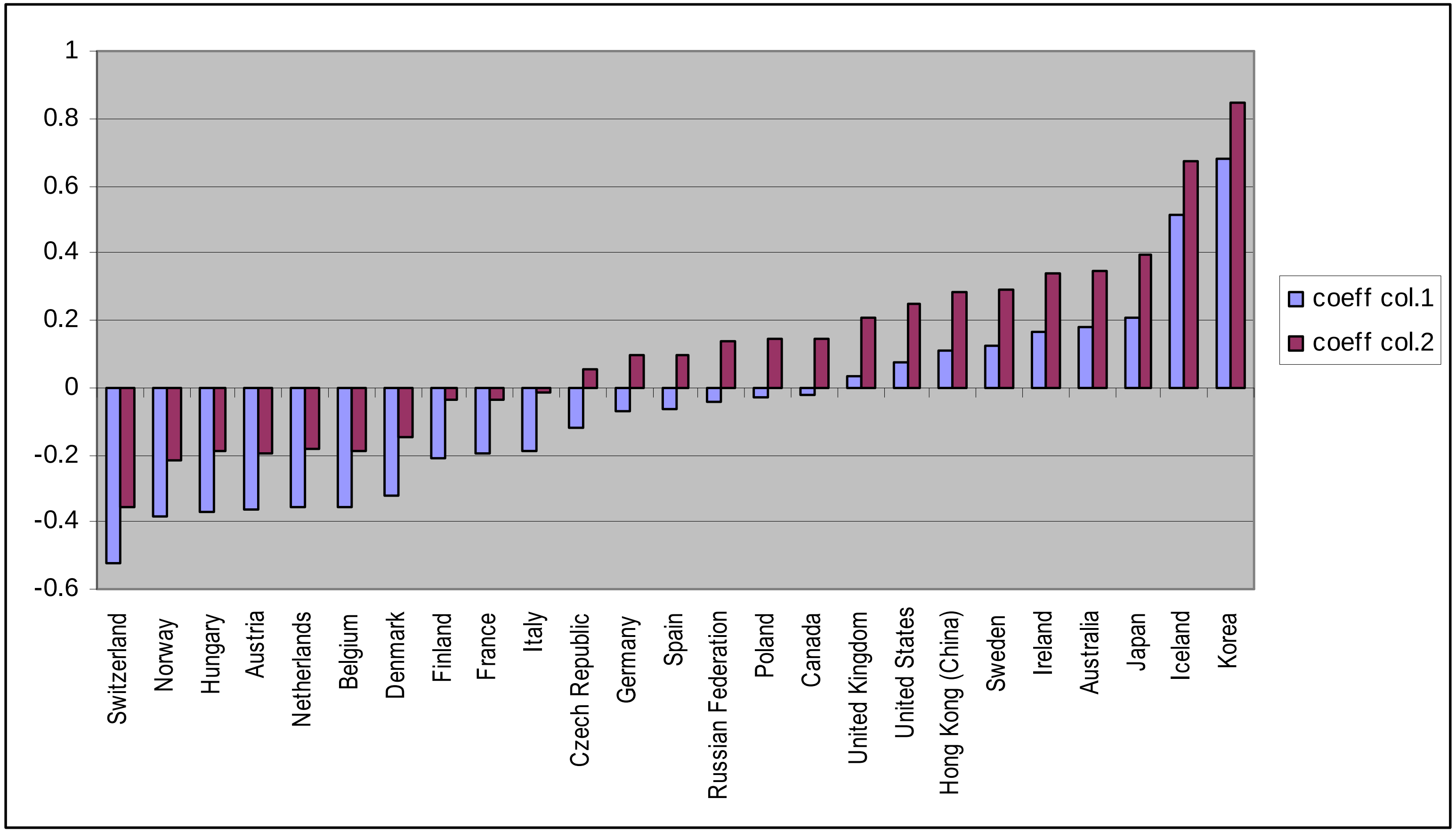

Figure 2 – Quantile regressions: returns to cooperative/competitive attitudes – PISA 2003