Should you compete or cooperate with your schoolmates ?

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Abstract

This paper presents a simple model showing that free riding incentives lead to an insufficient degree of cooperation between schoolmates, which in turn decreases the overall achievement. A cooperative learning approach may instead emerge when competitive behaviour is negatively evaluated by schoolmates, especially when the class is more homogeneous in terms of students' characteristics. Empirical evidence supporting our model is found using the 2003 wave of the PISA survey. A competitive learning approach has a positive individual return (higher in comprehensive educational systems), while student performance increases with the average cooperative behaviour, particularly in tracked educational systems.

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1. Introduction

Educational research can be broadly divided into two main bodies. The first one treats schooling as something that is done to students rather than something that is done by students, as in the education economics literature that estimates educational production functions (see Monk, 1990). Students are considered as the "raw material" that is combined with other inputs (typically school resources) into the educational production function to produce an output that is often measured in terms of schooling attainment or school grades. Hence, students are given a completely passive role and little insight is given into the importance of student behaviour and student attitudes for educational outcomes. On the other extreme, the second type of research, which will be partly reviewed below, is largely psychological and pedagogical and often based on case studies that put the student and the teacher at the core of the learning process and that typically refuse any generalisation across students, schools or countries.

In this paper we try to bridge the two streams of literature. From pedagogical and psychological literature we borrow the idea of the centrality of students' attitudes and behaviours in the learning process, while from educationalist research, which found a positive relation between group-learning and knowledge, we investigate the theoretical implications of students' competitive and cooperative behaviours for learning. At the same time we use a research tool typical of education economists, i.e. the "educational production function" and an approach based on the investigation of large data sets rather than of small case studies. 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). Despite the disadvantage of requiring a higher degree of generalization because we have much less information on the group than in case studies, we think that a large scale survey offers nonetheless some clear advantages such as the opportunity to investigate empirical regularities that go beyond a single class or a single school.

While the economists did not analyze the learning process from the student's cooperation-competition point of view, the educationalists' research on the matter is rather extensive. We summarize here some of their contributions, with the main purpose of stressing the findings that are also relevant from an economic point of view.[1]

The learning process is affected both by intrinsic and by extrinsic motivation. The latter comes from the external environment, outside the person, who acts with the anticipation of punishments and rewards, such as getting teacher and peer praise, acquiring a good grade, obtaining parental reward. For instance, earning high marks may enhance learning whenever marks are important to students as signals for either the continuation of the educational career, or for potential employers in the labour market. In contrast, intrinsic motivation occurs when the learning activity and the learning environment *per se* elicit motivation, because

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[1] See Abrami et al. (2000) and Watkins (2005) for a thorough review of the literature. Strijbos and Fischer (2007) discuss methodological issues in interdisciplinary research on collaborative learning.

the student finds studying enjoyable and acquiring knowledge is a reward by itself. According to Malone and Lepper (1987), the factors that enhance intrinsic motivation can be divided into individual factors (e.g. curiosity) and interpersonal ones (e.g. feeling satisfaction by helping others, or when others recognize and appreciate one's accomplishments).

Educationalists usually consider intrinsic motivation as more effective than the extrinsic kind 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 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

[2] See for instance Watkins (2005) and Cowie and Berdondini (2001).

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,[3] and that high achievers are more inclined to gain recognition of their level of ability through competition in the class.[4] All these features also characterize the model that is presented in the next section.

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 literature stresses the advantages of cooperative learning.[5] 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 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:

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[3] 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*).

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

[5] 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.

> *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).

As the quotation makes 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 (the public good) 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 expand this line of argument by proposing a model where each student allocates his/her effort between two types of activity, cooperation or competition. Cooperation may be thought to correspond to group learning, providing 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.

In the second part of the paper, we bring the theoretical predictions of the model to the data, using the PISA 2003 survey, where students self-declare their learning attitudes towards cooperation and competition. Although such a dataset does not allow us to observe the process that effectively occurs in 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 be competitive, but a group advantage in adopting cooperative strategies.

The structure of the paper is as follows. In Section 2 we present a model that frames cooperation and competition in learning, providing some testable theoretical predictions. In Section **Errore. L'origine riferimento non è stata trovata.** we provide some empirical evidence drawn from an international student survey, which contains information about student learning attitudes and performance. Section **Errore. L'origine riferimento non è stata trovata.** concludes.

2. Theoretical Framework

The relative performance within one's school is a useful signal of students' abilities, which certainly affects their likelihood of finding a good job. However, such a signal is imperfect, and employers adopt other devices, like interviews, to compare candidates who often come from different schools. There are therefore 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. The second is an absolute component, not captured by the relative ranking, that needs to be evaluated in order to compare students coming from different schools.

Many studies in education, psychology and economics document how children may be more clearly motivated by short-run gratification (corresponding to a relative performance) rather than less tangible long-run rewards (which can be assimilated to an absolute performance - see Chelonis, Flake, Baldwin, Blake and

Paule 2004, Harbaugh and Krause 1998, Bettinger and Slonim 2006). However, in what follows we focus on the absolute level of knowledge, thereby assuming that students encompass the long run consequences of their choices. Such a framework, which turns out to be much simpler from the algebraic point of view, defines a lower bound to competition. If we were to assume that students also care about being in the highest possible position in the ladder, we would stress more their incentives to compete, without changing the main implications of the model.

2.1 The Production of Knowledge

We assume that each student cares about his/her optimal level of knowledge, which can be produced privately (through individual learning activities) or collectively (through group learning).

The simplest way to model the decision of time allocation is to consider that learning has an opportunity cost which is identical among students, and for simplicity described by a quadratic disutility function. On the contrary, the choice between individual or group learning requires clarifying the production process of knowledge.

In what follows, we partly deviate from the educational literature previously outlined, which views "cooperative learning" as that mainly taking place in class and induced by teachers. Indeed, we adopt a different and broader concept of "cooperative learning" (or "group learning"), which refers to situations where students are free to choose how to allocate their time 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 form.

We assume that *private knowledge* is produced through individual learning. This requires not sharing knowledge acquisition with classmates, possibly to be recognised as better than others in class.[6] 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 students learn the meaning of a specific word on their 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 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 homework: the time students spend solving their assignments individually enters the definition of effort devoted to the production of private knowledge. In contrast, if students work in groups, what they learn by doing homework is classified as public knowledge.

[6] For the sake of simplicity in the theoretical model we adopt as the relevant student's community a class. However, group learning (or cooperative learning) may also take place among students from different classes but from the same school, especially when we consider student homework. In fact, due to the nature of the data used in the empirical analysis (OECD PISA) we will consider a school as the relevant student community. Alternatively, one might assume that classes' behaviours are homogenous within the same school.

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 to allocate 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 producing public knowledge. Using one of the aforementioned examples, this corresponds to a student participating in group work only to get the solutions of the homework painstakingly elaborated by his/her classmates, and then spending most of the 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 (e.g., because larger communities make individual interaction more difficult). In the limit case where there is a continuum of agents and the individual contribution is negligible, the optimal contribution to the production of public knowledge is equal to zero (which we can indicate as a "purely competitive outcome").

The simplest way of formalizing such a framework is the following:[7]

[7] Identical results are obtained by means of a Cobb-Douglas utility function subject to an explicit time constraint, provided that the exponents are chosen appropriately (in order to obtain meaningful results) and that the upper bound of the distribution of ability is kept sufficiently low to ensure a positive amount of leisure. In that case the solutions for p^* and s^* can be interpreted as the fraction of time devoted to each type of learning. Notice also 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

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

where U_i is individual utility, p_i is the time 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. The time devoted to group learning (s_i) generates instead *public knowledge* ($\tilde{s}$), defined as

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

We assume that the production of public knowledge is decreasing in students' heterogeneity as represented by the standard deviation of their ability (σ_α). The underlying idea is that peer effects are more intense in more homogenous environments. Therefore, mixing extremes that are too far apart implies a loss in terms of knowledge on both sides: the best students waste (part of) their time interacting with the least brilliant students, if the latter do not fully grasp the arguments put forward by the former.

to both tasks. If a student cares only about the total time spent studying, but she is indifferent about its allocation between individual or group learning, the outcome will be a corner solution where she spends her time only on the task yielding the highest marginal return. In contrast, modelling two separate costs allows internal solutions to emerge, because it implies that students prefer to diversify time allocation between the two activities. We regard this as a more appropriate model, since we rarely observe students adopting extreme behaviours like "pure competitor" or "pure cooperator".

Moreover, 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: we have to make sure that $\sigma_\alpha < 1$. This happens, for instance, when ability is uniformly distributed over a unitary support (i.e. $\alpha \approx U[0,1]$), which also has the great advantage of simplifying the algebra.

From the first order conditions the following optimal choices emerge:

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

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

with the contribution to public knowledge that decreases in students' heterogeneity and group size, getting to zero when the number of students is sufficiently large. Abler students are those who contribute more, 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).

The first testable implication of these joint assumptions is that the effort exerted in the production of both private and public knowledge is increasing in ability. The latter increases more than the former whenever $\sigma_\alpha n < 1$, i.e. when students belong to a small and homogeneous class.

As already mentioned at the beginning of this section, the optimal amount devoted to the production of private knowledge would be even higher if the relative evaluation in class is explicitly modelled. This happens because at the margin the density of knowledge (intuitively, the fraction of students that can be overcome by increasing one's effort by a small amount) also affects the choice, making individual learning more rewarding.[8]

We define a learning approach as *cooperative* when a larger amount of time is devoted to the production of public rather than private knowledge:

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

A necessary condition to always observe a cooperative behaviour at individual level is $\sigma_\alpha n < 1$, i.e. to belong to an extremely small and homogeneous class. Notice that when this condition is satisfied, all students in the group display a cooperative behaviour regardless of their ability level.

Therefore, to avoid this trivial solution of the model as well as to ensure that group learning has a fostering effect on knowledge we assume that:

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[8] This amounts to adding 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 knowledge, given that public knowledge is the same for everybody. If only the relative evaluation matters, on the other hand, such a term should replace the private knowledge term in (1).

$$\frac{1}{n} < \sigma_n < 1.$$

Could we expect to observe a degree of cooperation larger than that implied by self-interest? The answer is positive, if we modify individual preferences, for instance assuming that students enjoy cooperative learning because of the opportunity 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 activities inside and outside the class. We model the fact that students care about what their classmates think, turning our model into a psychological game in which opponents' beliefs enter the utility function:

$$U_i = \alpha_i p_i + \tilde{s} - \frac{1}{2}(p_i)^2 - \frac{1}{2}(s_i)^2 - \mu(p_i - s_i), \quad \mu > 0. \tag{6}$$

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.[9]

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

[9] Alternatively, we might interpret the last term as an altruistic component, which ensures a positive utility when the student behaves in a cooperative manner.

$$\arg\max_{p_i}[U_i] = p_i^* = \alpha_\mathrm{i} - \mu \tag{7}$$

$$\arg\max_{s_i}[U_i] = s_i^* = \frac{\alpha_\mathrm{i}}{\sigma_\alpha \mathrm{n}} + \mu\ . \tag{8}$$

The opinion of 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 dominating the latter since we assumed that $\sigma_\alpha n > 1$. In other words, the incentive to cooperate does not change significantly in accordance with individual ability whenever n is sufficiently large and/or the class is very heterogeneous.

The threshold level of ability that divides the students characterized by a competitive learning approach from those characterized by a cooperative learning approach is obtained by equating equations (7) and (8). *Competitive learning* occurs for all students characterised by a level of ability:

$$\alpha_i > \frac{\sigma_\alpha n}{\sigma_\alpha n - 1} 2\mu \tag{9}$$

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.

A second testable implication of our model is therefore that *ceteris paribus* we expect 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 mimics the outcome of job market interviews concerning pupils from different classes/schools. We define the total knowledge K of a class simply as the sum of the total knowledge acquired by each student:

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

where $K_i = \alpha_i p_i^* + \tilde{s}$, given that individual total knowledge is the outcome 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 (s_i) and of individual ability (α_i). In this way, 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 its inputs, which in our model is ensured by the assumption that $\sigma_\alpha < 1$, the total knowledge of a class turns out to be increasing in the degree of cooperation within the class by construction. When class (group) size is sufficiently large, i.e. $n \to \infty$, and reputation about being a cooperative person is irrelevant, i.e. $\mu = 0$, a purely competitive outcome emerges with individual contribution to public knowledge going to zero: as a consequence also $\tilde{s} = 0$. The total knowledge, assuming ability being uniformly distributed between zero and one, $\alpha \approx U[0,1]$, is simply

$$K = \int_0^1 k_i d\alpha = \int_0^1 \alpha p_i^* d\alpha = \int_0^1 \alpha^2 d\alpha = \left[\frac{1}{3}\alpha^3\right]_0^1 = \frac{1}{3} \qquad (11)$$

When the opinions of classmates enter students' utility functions, affecting their propensity to cooperate, the picture changes sharply, since public knowledge becomes positive also in the case of an infinitely large group:

$$\tilde{s} = \frac{1}{\sigma_\alpha}\int_0^1 \alpha s(\alpha) d\alpha = \frac{1}{\sigma_\alpha}\int_0^1 \alpha\mu d\alpha = \frac{\mu}{\sigma_\alpha}. \qquad (12).$$

Similarly, total knowledge increases (given $\sigma_\alpha < 1$ by assumption):

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

The same results hold qualitatively when the number of students in the group is finite. When the incentive to cooperate is based on the individual return only, i.e. $\mu = 0$, the public knowledge coming from cooperative learning is:

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

and total knowledge therefore is:

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

When their classmates' opinion enters students' utility functions, public knowledge increases and becomes:

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

while total knowledge is also greater (since $\sigma_\alpha < 1$ by assumption) and equal to:

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

Of course, this also translates into a higher average knowledge in the class. A 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 produced and therefore the larger the amount of average knowledge. In other words, total knowledge should be increasing in the reallocation of effort from individual to group learning

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 would be to make social preferences a (decreasing) function of students' heterogeneity $\mu(\sigma_\alpha)$.[10] As a consequence, tracked educational systems, characterized by a more homogeneous body of students within schools (since they are often sorted by ability into tracks), should display a relatively higher degree of cooperation and a lower degree of competition.

Moreover, since we believe that group working is more productive when involving extremes that are not too far apart, we have modelled public knowledge as a decreasing function of students' heterogeneity. If this is the case, tracked educational systems should also display a higher return to aggregate cooperative behaviour.

[10] This prediction is for instance in line with findings in Alesina and La Ferrara (2000) that participation in social activities is lower in more unequal and heterogeneous communities.

In a nutshell what happens is that choosing the optimal amount of learning based on individual incentives only might be Pareto inferior. 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, as well as belonging to a small and homogeneous group, may partially overcome such inefficiency.

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

- the effort exerted in the production of both private and public knowledge increases ability;
- the "best" students (i.e., most able) should be characterized by a competitive learning approach, while the opposite holds for the worst students;
- students' knowledge should increase with individual competitive behaviour and with average cooperative behaviour (while no direct effect should be associated with private cooperative behaviour or with 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 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 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 and cooperative learning 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 OECD researchers (using principal component analysis) into two variables (COOPLRN and COMPLRN).[11]

[11] 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,

How can we use the data from PISA survey to test the predictions 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 a function of individual endowments (that we termed ability) and behaviour (in terms of effort towards individual and group learning). Unfortunately, the PISA dataset does not contain any reliable proxy for innate 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 characteristics can be considered as proxies for the (observable) component of ability. Moreover, these observable parental characteristics (e.g., education) will also be partly correlated with a child's innate ability (due to transmission of genes). Any unobservable component of ability will then end up in the residual of any regression of students' test scores on family background.

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.

p.134). However, in the PISA case the statement refers to individual aptitude and not to class perception, and therefore we feel less troubled in using it.

We use students' test scores as a measure of the knowledge possessed by each student.[12] We take students' attitudes expressed with respect to competition Vs. cooperation with other students as proxies for the allocation of their effort in the direction of individual learning or group learning, respectively. 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 and/or there are too many missing values in family background information (101,472 cases excluded).[13] By excluding individuals in schools with less than 10 students we lose another 2,694 observations. We also omit students not enrolled in the modal grade (43.269), because they could represent biased sub-samples (either in terms of ability, or in terms of attitudes toward cooperating with others, for repeating students who might face rather dissimilar peers). Finally, keeping only the observations without missing information on all the covariates we are left with 99,727 students spanning 24 countries (descriptive statistics are summarized in Table 1, while Table 2 displays the breakdown by country).

Under this set of assumptions, let us compare the predictions of our model with the empirical evidence in the data. We know from the extensive literature on

[12] 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.

[13] The countries excluded are Brazil, France, Greece, Indonesia, Latvia, Liechtenstein, Luxembourg, Macao (China), Mexico, New Zealand, Portugal, Slovakia, Thailand, Tunisia, Turkey, Uruguay, and Yugoslavia.

student performance (see among others Wößmann, 2003, or Ammermüller, 2005) that individual test scores are positively correlated with a bunch of variables, although scholars fiercely 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, index of 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).

Let us then consider learning attitudes. The theoretical model predicts that both effort exerted producing individual knowledge and time devoted to cooperation should increase with ability, therefore displaying a positive correlation. The sample correlation between the competitive and cooperative attitude is a statistically significant 0.29.

Our theoretical model has been set up assuming that students exhibit either a competitive learning approach (whenever $p_i^* > s_i^*$) or a cooperative one (in the opposite case), and that they would be more likely to adopt the former behaviour the higher their ability. However, questions concerning a student's 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 students by taking the difference between the two opinions. The assumption underneath is that a competitive learner is more likely to express stronger support for competitive rather than cooperative behaviour .

In Table 3 we have reported the correlation of this measure (COMPLRN minus COOPLRN) with two alternative definitions of family background, used to proxy the observable component of students' ability. 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 contains information related to household possessions (variable ESCS - index of Economic, Social and Cultural Status). In both cases the dependent variable exhibits a positive correlation with the measures of family background, in line with the prediction of the model that the effort exerted in the production of private knowledge should be increasing in ability more than the effort exerted in group learning. We also find evidence of the fact that girls have less competitive and more cooperative attitudes than boys.

We remind the reader that the incentives to exert effort in group learning were parameterised on μ (measuring the utility impact of classmates' opinions) and σ_α (the heterogeneity in students' abilities). We argued that in more homogeneous environments social control is stronger, and students should therefore care more about the perception of their behaviour by other classmates.

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 in such countries.[14] In the data, we find evidence consistent with this prediction. 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 to be prevalent among Nordic countries (Sweden being an exception), while competitive attitudes dominate in Anglo-Saxon and Eastern Asian countries. [15] Moreover, cooperative learning is more frequent among countries adopting a tracked educational system. However, we cannot properly test for the presence of different levels of cooperation/competition across countries. The reason is that countries may differ on many other dimensions (including religion, cultural attitudes, strength of family ties, etc.), which may affect the average degree of cooperation/competition over and above the type of educational system. Hence, this drawback prevents us from safely interpreting as supporting evidence for our model the fact that most of the countries characterized by tracked educational systems exhibit low fixed effects in Figure 1, where the dependent variable is the difference between the competitive and the cooperative behaviour.

We now consider the correlation between acquired knowledge, individual ability and competitive/cooperative attitudes. In Table 4 we report OLS estimates of the

[14] 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.

[15] Curiously enough we find that Asian countries generally rank high in terms of competitive attitudes. However, despite common beliefs that Confucian heritage favours cooperation, Phuon-Mai et al. (2005) show that the culture itself creates an obstacle to effective cooperation in learning.

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 school.

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 to find 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 of 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. We also include two (admittedly imperfect) proxies for the size of the relevant student group: the school size and the student/teacher ratio, since we want to see whether the incentives to cooperate decline in larger communities (i.e. the returns to cooperation are lower in large groups). When we consider individual 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. In other words, an individual competitive attitude is positively associated with individual acquisition of knowledge, while a cooperative attitude shows a negative correlation with it,[16] but only in

[16] Notice that there is no causal implication in these correlations, because in accordance with our model both variables display a spurious correlation with the unobservable component of individual ability.

comprehensive educational systems. Notice that these individual incentives to compete are strengthened in larger communities (higher student/teacher ratios) and/or in more heterogeneous environments (school systems that are not tracked). This is in line with the prediction of the model that since tracked educational systems are characterized by a lower heterogeneity they should also display a higher return to cooperative attitudes.

More surprising are the correlations with school-level (i.e. collective) attitudes reported in column 2 of Table 4. Here we observe a reversal of signs. Other things being 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 considering the institutional features of a country, we observe that the average competitive attitude is associated with a slightly more negative premium in comprehensive systems, while the reward to the prevalence of average cooperative attitudes is twice as large in tracked educational systems. If we consider that tracked educational systems are more homogeneous in terms of student abilities (since tracking is usually done according to children's potential ability and past school performance) our results suggest that cooperation is more likely among classmates that are more similar to one another.

In column 3 of Table 4 we combine both individual and collective attitudes, and both sets of results are confirmed. Results therefore remind us of a hawk-dove game insofar as it pays to be competitive while all the others are cooperative, because one obtains the benefit both of the private good (individual learning) and of the public good (the public knowledge). Unlike the hawk-dove game, however, this is not an anti-coordination game. In contrast, all students end up doing the same thing in equilibrium, namely investing an inefficiently low amount of time in the production of public knowledge. This situation is quite consistent with the results of our theoretical model, in which individual knowledge increases with individual competitive behaviour and with average cooperative behaviour. However, the model does not consider negative externalities from the average competitive behaviour (which for instance could be rationalized by means of sabotage), and it does not predict a negative impact of individual cooperative behaviour.

As to the results concerning aggregate behaviour, we know from other studies (Hanushek and Wößmann, 2006) that a tracked educational system has a negative impact on average students' performance. However, in these studies it is sometimes hard to identify the effect of tracking due to the potential correlation with other unobserved country characteristics. In this respect, we include country fixed effects in our analysis (which partly capture intercept effects of tracking and country-level unobservables) while investigating the differential effect of tracking on students' performance via its interaction with students' level of cooperation. We find that test scores are higher when average cooperation is higher, but in tracked systems only. In our view this reinforces our argument: tracked systems might be associated with a lower student performance (intercept effect), but at the same time tracking might have a positive effect on student knowledge both by increasing the level of student cooperation and by raising the return to cooperation. This means that the effect of tracking might turn out to be even more negative when these effects on student behaviour are neglected and it might even turn positive when they are accounted for. This is also consistent with the educationalists' claim that group learning enhances intrinsic motivations, and consequently knowledge, provided that students are not too different from one another.

Finally, we want 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 according to our model). 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 also the effect of the interaction with the dummy "tracking") are also plotted in Figure 2. 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" students have lower disincentives when preferring cooperative learning. As far as tracked educational systems are concerned, incentives to individual competitive behaviour are lower and roughly constant in student performance, while disincentives for individual cooperative attitudes disappear irrespective of the students' level of knowledge.

4. Conclusions

In the present paper we show another occurrence of "failure of composition". A theoretical model shows 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 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.

We then bring these implications to the data, using a survey conducted in 2003 by the OECD-PISA consortium. In this survey students express their preferences towards competitive or cooperative learning. We study the correlation between these attitudes, family background and student test scores. 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' attitudes: learning in a competitive environment is detrimental to knowledge, while a cooperative environment favours individual performance.

We also analyse whether these conclusions, as predicted by our model, are strengthened in more homogenous environments, which are represented by tracked educational systems. We find that tracked systems raise substantially the returns to cooperation both at individual and at aggregate level, probably thanks to a greater homogeneity of the student body.

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 are increasing in student performance, particularly in comprehensive educational systems.

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Tables and Figures

Table 1 - Descriptive statistics – PISA 2003

Variable	Obs	Mean	Std. Dev.	Min	Max
Test score in mathematics	99,727	530.403	84.839	192.740	848.995
Female	99,727	0.515	0.500	0	1
Age	99,727	15.796	0.287	15.170	16.420
Highest parental occupational status	99,727	50.417	16.072	16	90
Highest parental education in years of schooling	99,727	13.380	2.850	0	17
Computer facilities at home	99,727	0.236	0.893	-1.676	1.051
Index of home possessions	99,727	0.174	0.922	-3.787	1.940
Hours All homework	99,727	6.214	5.648	0	30
How many books at home	99,727	3.709	1.358	1	6
Student/teacher ratio	99,727	13.584	4.630	1.379	70
School size	99,727	707.070	437.801	19	6000
Competitive learning	99,727	-0.035	0.966	-2.844	2.450
Co-operative learning	99,727	-0.021	0.967	-3.134	2.742
Tracking*	99,727	0.471	0.499	0	1

* Countries classified as tracked according to the distribution of the type of secondary school attended (variable PROGN): Austria, Belgium, Czech Republic, Denmark, 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	7,491	7.51	7.51
Austria	1,863	1.87	9.38
Belgium	4,935	4.95	14.33
Canada	16,362	16.41	30.73
Czech Republic	2,684	2.69	33.43
Denmark	2,676	2.68	36.11
Finland	4,563	4.58	40.69
Germany	1,925	1.93	42.62
Hong Kong (China)	2,329	2.34	44.95
Hungary	2,362	2.37	47.32
Iceland	2,531	2.54	49.86
Ireland	1,491	1.50	51.35
Italy	8,390	8.41	59.77
Japan	3,681	3.69	63.46
Korea	4,402	4.41	67.87
Netherlands	1,229	1.23	69.10
Norway	2,767	2.77	71.88
Poland	3,937	3.95	75.83
Russian Federation	3,112	3.12	78.95
Spain	5,930	5.95	84.89
Sweden	3,583	3.59	88.48
Switzerland	4,410	4.42	92.91
United Kingdom	4,914	4.93	97.83
United States	2,160	2.17	100.00
Total	99,727	100.00	

Table 3 – Competitive attitude and family background – PISA 2003

	1	2
	complrn-cooplrn	complrn-cooplrn
female	-0,285	-0,287
	[36.94]***	[37.18]***
Highest parental occupational status	0,002	
	[6.20]***	
Highest parental education in years of schooling	0,008	
	[5.63]***	
Index of socio-economic and cultural status		0,052
		[11.16]***
Australia	0,166	0,344
	[7.34]***	[27.32]***
Austria	-0,369	-0,19
	[7.46]***	[4.15]***
Belgium	-0,373	-0,193
	[13.58]***	[9.98]***
Canada	-0,041	0,138
	[1.73]*	[10.31]***
Czech Republic	-0,133	0,049
	[4.51]***	[2.28]**
Denmark	-0,349	-0,163
	[10.91]***	[6.47]***
Finland	-0,218	-0,036
	[7.98]***	[1.85]*
Germany	-0,101	0,075
	[2.52]**	[2.08]**
Hong Kong (China)	0,102	0,284
	[4.38]***	[15.41]***
Hungary	-0,384	-0,198
	[12.55]***	[7.95]***
Iceland	0,502	0,671
	[13.66]***	[22.40]***
Ireland	0,161	0,344
	[4.01]***	[9.50]***
Italy	-0,196	-0,015
	[7.51]***	[0.78]
Japan	0,198	0,394
	[6.50]***	[16.98]***
Korea	0,67	0,851
	[29.79]***	[58.93]***
Netherlands	-0,361	-0,179
	[11.25]***	[6.73]***
Norway	-0,39	-0,216
	[10.50]***	[6.99]***
Poland	-0,044	0,14
	[1.81]*	[8.42]***
Russian Federation	-0,051	0,14
	[1.87]*	[7.25]***
Spain	-0,08	0,094
	[3.15]***	[4.86]***
Sweden	0,112	0,289
	[3.77]***	[12.57]***
Switzerland	-0,547	-0,365
	[16.32]***	[12.60]***
United Kingdom	0,019	0,199
	[0.74]	[10.76]***
United States	0,066	0,246
	[2.01]**	[9.28]***
Observations	99,727	99,727
R-squared	0.07	0.07
Log likelihood	-152,094	-152,084

Robust absolute value t statistics in brackets - errors clustered by school
* 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
Female	-15.121	-18.083	-15.520
	[22.45]***	[27.57]***	[23.34]***
Age of student	3.569	3.277	3.339
	[3.74]***	[3.44]***	[3.52]***
Highest parental occupational status	0,501389	0,504167	0,501389
	[36.46]***	[36.58]***	[36.59]***
Highest parental education in years of schooling	1.393	1.396	1.360
	[12.22]***	[12.29]***	[12.00]***
Computer facilities at home	6.762	6.830	6.732
	[15.14]***	[15.32]***	[15.10]***
Index of home possessions	6.230	6.659	6.269
	[13.25]***	[14.17]***	[13.42]***
Hours All homework	1.359	1.524	1.367
	[19.29]***	[22.32]***	[19.88]***
How many books at home	12.286	12.222	12.214
	[48.11]***	[48.07]***	[48.19]***
Teacher/student ratio	-0.302	-0.221	-0.220
	[1.79]*	[1.34]	[1.33]
School size	0.015	0.014	0.014
	[9.05]***	[8.70]***	[8.71]***
Competitive attitude	7.225		9.663
	[6.35]***		[10.47]***
Co-operative attitude	-5.357		-6.371
	[5.02]***		[7.13]***
Competitive attitude x schoolsize	0.001		0.000
	[1.44]		[0.58]
Cooperative attitude x schoolsize	-0.001		-0.001
	[1.26]		[0.96]
Competitive attitude x student/teacher ratio	0.214		0.094
	[2.68]***		[1.46]
Cooperative attitude x student/teacher ratio	-0.011		0.029
	[0.14]		[0.46]
Competitive attitude x tracking	-5.230		-5.246
	[7.48]***		[9.00]***
Cooperative attitude x tracking	6.588		6.275
	[10.46]***		[11.08]***
school average competitive attitude		-32.669	-36.229
		[5.09]***	[5.69]***
school average cooperative attitude		19.374	22.052
		[2.82]***	[3.27]***
school average competitive x tracking		-2.070	-0.562
		[0.44]	[0.12]
school average cooperative x tracking		18.492	15.693
		[3.25]***	[2.79]***
school average competitive x schoolsize		0.011	0.010
		[2.46]**	[2.37]**
school average cooperative x schoolsize		-0.009	-0.008
		[1.41]	[1.39]
school average competitive x student/teacher ratio		1.626	1.580
		[3.56]***	[3.50]***
school average cooperative x student/teacher ratio		-1.009	-1.033
		[1.99]**	[2.08]**
Observations	99,727	99,727	99,727
R-squared	0.25	0.24	0.25
Log likelihood	-570304.59	-570829.40	-570137.30

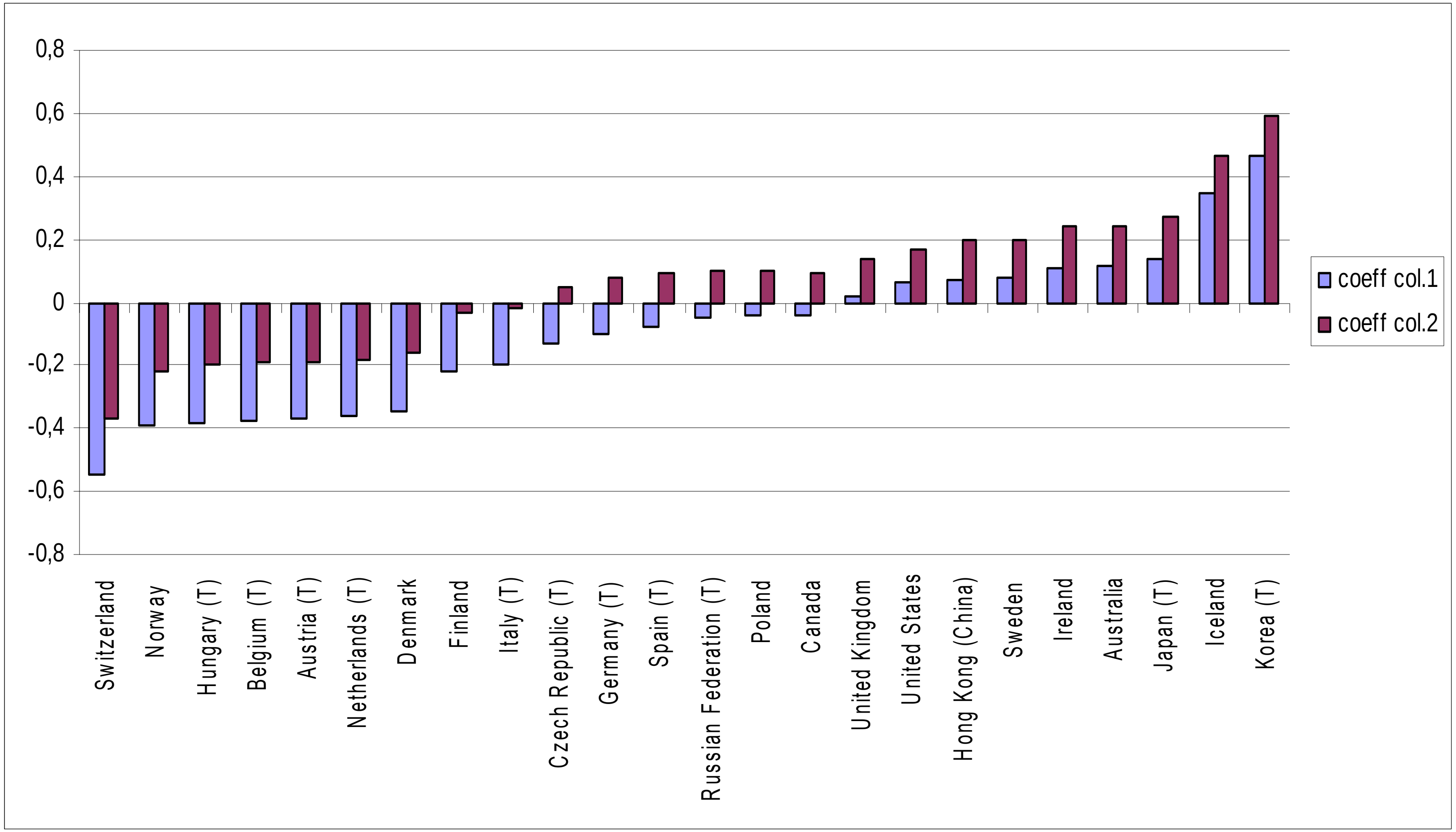
Robust absolute value t statistics in brackets * significant at 10%; ** significant at 5%; *** significant at 1%
errors clustered by school – country fixed effects included

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

	1 q25	2 q50	3 q75
Female	-12.591	-16.404	-19.873
	[17.73]***	[24.10]***	[27.16]***
Age of student	0.411	4.01	4.220
	[0.35]	[3.80]***	[3.81]***
Highest parental occupational status	0.768	0.750	0.670
	[34.99]***	[36.47]***	[29.00]***
Highest parental education in years of schooling	1.394	1.456	1.485
	[9.74]***	[9.96]***	[10.71]***
Computer facilities at home	7.092	6.863	7.116
	[12.76]***	[16.55]***	[14.11]***
Index of home possessions	7.765	5.998	3.931
	[13.10]***	[12.47]***	[7.44]***
Hours All homework	1.642	1.373	1.022
	[26.26]***	[23.26]***	[16.96]***
How many books at home	11.574	12.965	13.980
	[42.92]***	[44.81]***	[47.42]***
Teacher/student ratio	-0.220	-0.308	-0.242
	[2.74]***	[4.04]***	[2.81]***
School size	0.014	0.015	0.015
	[14.67]***	[16.14]***	[16.11]***
Competitive attitude	7.347	10.499	13.273
	[5.95]***	[9.99]***	[10.13]***
Co-operative attitude	-3.130	-7.269	-8.111
	[2.26]**	[7.16]***	[6.61]***
Competitive attitude x schoolsize	0.000	0.000	-0.000
	[0.31]	[0.61]	[0.26]
Cooperative attitude x schoolsize	0.000	-0.001	-0.001
	[0.03]	[1.99]**	[1.72]*
Competitive attitude x student/teacher ratio	0.099	0.065	0.047
	[1.10]	[0.81]	[0.50]
Cooperative attitude x student/teacher ratio	-0.154	0.108	0.159
	[1.65]*	[1.49]	[1.93]*
Competitive attitude x tracking	-3.447	-5.863	-7.298
	[4.43]***	[10.04]***	[9.94]***
Cooperative attitude x tracking	5.521	7.791	7.347
	[6.39]***	[10.53]***	[8.57]***
school average competitive attitude	-38.419	-29.301	-31.195
	[8.71]***	[7.99]***	[7.28]***
school average cooperative attitude	19.13	19.902	26.871
	[4.00]***	[5.31]***	[7.21]***
school average competitive x tracking	-2.338	1.926	3.328
	[0.76]	[0.73]	[1.25]
school average cooperative x tracking	12.887	17.400	17.801
	[3.78]***	[5.80]***	[6.07]***
school average competitive x schoolsize	0.012	0.012	0.012
	[4.05]***	[4.26]***	[4.43]***
school average cooperative x schoolsize	-0.012	-0.010	-0.005
	[3.70]***	[2.91]***	[2.38]**
school average competitive x student/teacher ratio	1.631	0.783	0.949
	[5.83]***	[2.89]***	[3.13]***
school average cooperative x student/teacher ratio	-0.552	-0.846	-1.645
	[1.69]*	[2.75]***	[6.18]***
Observations		99,727	
R-squared	0.1321	0.1419	0.1448

Bootstrap absolute value t statistics in brackets (100 replications)
* significant at 10%; ** significant at 5%; *** significant at 1%
Country fixed effects included

Figure 1 – Country fixed effect when predicting "competitive attitudes" – PISA 2003



Note. The graph shows the fixed effects estimated in Table 3. (T) indicates tracked educational systems.

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