DemoSoc Working Paper

Paper Number 2013--50

Social capital and cognitive attainment

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Marzo, 2013

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Abstract

We review the different meanings that researchers have given to the concept of social capital, differentiate four types – bridging, bonding, linking, and overheads –, and discuss their different functions as public, club, and common goods.

For each form of social capital we distinguish its productivity (a collective characteristic) from the factors that account for individual's differential access to its returns, and propose alternative ways for measuring each.

We show the utility of our theoretical and measuring approach by analyzing the impact of the each form of social capital on 15 year-old students' cognitive attainment across OECD countries, using 2006 PISA data.

The results show that students' cognitive attainments are a direct function of the richness or productivity of each form of social capital and of students' degree of access to each.

Introduction

Social capital is an increasingly popular concept, partly because of the vagueness of its definition. For example, Adler and Kwon (2002) defined social capital as ‘the good-will resulting from social relations’. This vagueness facilitates multiple operationalizations and measurements but can also generate misunderstandings (Portes 2000). In this paper, we review concept’s many connotations, distinguishing social capital according to its functions as a public, club, or common good. We also differentiate the relational aspects that define social capital’s productivity from the access to its returns. We propose new measurements for each and investigate the association between all forms social capital and 15 year-old students’ cognitive attainment across OECD countries, using 2006 PISA data. Applying multilevel models adequate to the three levels at which social capital must be measured, we offer, for the first time, a complete account of the role played by all its forms on the acquisition of cognitive skills.

Social capital and its forms

There is no agreement on what social capital is, except on its being multifaceted (Portes 1998; Lin 1999). Sociologists traditionally distinguish three types: bridging social capital and bonding social capital of the support and the control kinds (Putnam 2000; Portes 2000; Burt 2009). Economists focus on social overheads capital (Hirschman 1958).

Bridging social capital stems from contact networks different from family and friends. Benefits derive from weak ties of acquaintance that foster “thin” trust and reciprocity (Gouldner 1960; Lin 1999). Weak ties are created by individual acts of brokerage which connect culturally dissimilar groups of equal standing, willing and capable of reciprocating (Burt 2009).

Bonding social capital serves two functions (Coleman 1988). First, it provides emotional, cognitive, or economic support to members of small groups of family and friends united through strong ties or frequent contacts in multiple life dimensions (Granovetter 1973; Li et al. 2005). Support is a byproduct of socialization, whereby general understandings and values are created, passed, and interiorized by group members (Coleman 1988; Lareau and Horvat 1999). Supportive social capital is sometimes equated with human capital, an innate ability that develops in combination with intense cognitive interactions between people (Portes 2000). More generally, it is seen as resulting from shared knowledge and meanings shaping members’ behaviors and requiring no reciprocation (Bourdieu 1984), i.e., arising among cognitive equals who understand and trust each other “thickly”.

Bonding social capital’s second function is to facilitate social control (Coleman 1993). Understandings and values must be enforced normatively, especially in mid-sized, situational groups with idiosyncratic social interactions (Li et al. 2005). Control ensures that group members act as expected by their status. In situational groups, control is enforced through informal norms, reputation, and moral force (Coleman 1993). Reputation regulates within-group roles based on calibrations of each other’s worth, distinguishing members vertically, and ultimately separating insiders from outsiders (Narayan 1999; Burt 2000). Some refer to it as linking social capital (Szreter and Woolcock 2004).

The final form of social capital is social overheads capital. It generates social returns or externalities via pooling of physical resources or management of existing and natural pools (McNutt 2000). Common infrastructures are a good example.

As Hayami (2009) argues, the peculiarities of each form of social capital can be best grasped by analyzing the goods they provide. In Samuelson’s classic two-dimensional taxonomy (1954), a good is rivalrous when its use by a party is at another’s loss; non-rivalrous otherwise. A good is excludable if the costs of barring third parties from using it are negligible; non-excludable otherwise. Four goods result from combining Samuelson’s rivalry and excludability criteria: private, common, club, and public goods. Social capital provides all types of goods except private. Its relational nature means that its benefits are collective and cannot be appropriated individually. Whether they take the form of public, club, or common goods depends on the specific type of social capital.

Bridging social capital is a public good. First, reciprocation requires that the exchanging parties provide equivalent, yet complementary, benefits to each other. This makes it non-rivalrous. Second, the costs of excluding third parties from the externalities of the exchange are high (Coleman 1988). New bridges foster trust in strangers among other group members, and offer new opportunities to gain access to the resources of other groups, thus helping create a community of overlapping group memberships (Stone 2003).

Bonding social capital, whether of the support or the control kinds, is a club good. It is non-rivalrous, for both parties in the relationship gain from it; and excludable, since outsiders can be easily barred from its use. The difference between bonds of support and of control is that the former occur among equals; the latter, between non-equals (McNutt 2000).

Social overheads capital is a common good. It is non-excludable because free-riding makes the costs of barring non-contributors from pool’s returns high; and rivalrous, because its use by a party is at another’s expense, for example, due to over-use, degradation or crowding. As rivalry makes free-riding unacceptable, rights over pools’ exploitation may be partly transferred to third parties to enforce contribution (e.g., the government), or pools' size restricted and managed within clubs (Olson 1965; McNutt 2000).

Measuring social capital's productivity and participation in its returns

Traditionally, the field has been split among those arguing that social capital must be measured at the macro- or meso-level (Coleman 1990; Putnam 1995), to capture the contextual effects of the structure of relations from which its stems, and those who think it should be measured at the micro-level (Lin 1999; Van de Gaag and Snijders 2002), to highlight its instrumental role for individuals. The former seek to measure social capital's productivity, as determined by the structural characteristics of the groups and communities that sustain it. The latter seek to capture individuals' benefits, by focusing on how much access or participation they have in its returns. The literature has focused primarily on measuring participation (Van der Gaag and Snijders 2002), neglecting communities and groups' structural characteristics, possibly because they are costly to measure with micro-data. This is regrettable because, while the resources mobilized by individuals when accessing social capital could explain part of its returns and even boost its productivity (Lin 1999), participation cannot grasp the externalities or contextual effects of social capital's relational nature. Fortunately, there is a family of available indicators that grasp social capital's productivity indirectly. Some do it by measuring the dispersion of economic, cognitive, and cultural resources across and within groups in a community. Indicators of dispersion are good proxies of the richness of social relations on which bridging and bonding social capital are based (Lin 1999; Bourdieu 1984). Others do it with indicators of groups and communities' stocks or levels of wealth that capture building or government capacity, and thus the productivity of social overheads (Bowles and Gintis 2002).

The nature of the goods provided by each form of social capital helps identify which relations must be captured by the indicator and the level at which they must do it: relations between groups at the macro- or community level, to apprehend the public nature of bridging social capital's externalities; relations among individuals at the meso- or group level, to grasp the restricted or club character of bonding social capital's contextual effects; and relations between and within groups at both the macro and meso levels, to capture the common nature of social overheads' externalities and their decreasing marginal returns as group's size increases.

While scarce, indicators of social capital's productivity exist in various research fields. Thus, political scientists have shown that trust, civicness, and democracy are facilitated when economic power is homogeneously distributed across groups (Lin 1999; Alesina and LaFerrara 2000; Costa and Kahn 2003). Other scholars have shown that the impact of cognitive (e.g., ethno-linguistic) homogeneity on wealth, law compliance, health etc., is beneficial within small groups, while has no effects at community (between-group) level after controlling for groups' economic statuses, possibly because cognitive homogeneity fosters in-group bonds of solidarity and mutual support (Portes and Vickstrom 2001; Alesina and LaFerrara 2005; Letki 2008).

Conversely, studies have shown that within-group economic inequalities help prevent social dysfunction in small and mid-sized ecologies like neighborhoods (Wilkinson and Pickett 2009; Hipp 2011), presumably because status differences act as control mechanisms and facilitate members' integration in situational groups. Finally, many ecological studies have analyzed the meso- and macro- effects of groups' (neighborhoods, schools') and communities' (countries, cities') wealth stocks or social overheads on individuals' life conditions, behavioral problems, or learning abilities, net of individual-level effects (Wößmann 2000; Chiu and Khoo 2005; Fuchs and Wößmann 2007; Hipp 2011).

In contrast to the sparseness of the indicators of social capital's productivity, there are many available indicators of participation in its returns. Participation in bridging social capital is generally recorded with variables measuring individuals' access to networks of acquaintances (Woolcock 1988; Lin 1999), distance from 'bridges' (Burt 1990), or frequency of participation in voluntary associations (Putnam 1995). Equivalent and readily available indicators of participation that better grasp the non-excludability nature of bridging social capital's goods are collective measures of social inclusion (or conversely, of social segregation) based on group's power (Portes 1995). These measures consider that individuals' participation in civic society and access to bridging social capital's returns is a function of groups' socio-economic resources.

As for linking social capital, participation is often measured with micro-variables that assess individual's acculturation or compliance with group's norms (Teske and Nelson 1974; Gans 2007). Examples include indicators of individuals' position in networks of personal contacts (Lin 2001), attachment to situational groups (Li et al 2005), or time spent in a group (Portes 1995). Migrant status is a simple and similarly valid indicator of acculturation which is readily available in survey research (Portes 1995).

When subjects' participation depends on internalizing group's general cognitive schemes and values, it is measured with indicators of human assimilation, or how much subjects communicate with other group members as equals and enjoy their support (Teske and Nelson 1974; Gans 2007). These indicators are direct (e.g., language proficiency) or indirect, based on human capital measures (e.g., parents' education, number of books at home). The latter rests on evidence that subjects with higher human capital self-select themselves or are selected into cognitively homogeneous groups more frequently than others (Coleman 1988; Wößmann 2000). Scholars, especially in the educational field, investigate the consequences that this result, which is often affected by policies that promote stratification in cognitive outcomes, has on equality of opportunity and the creation of human capital (Hanushek and Wößmann 2006).

Finally, economists measure participation in social overheads capital with indicators of individuals' economic integration or levels of private resources. Evidence from stratification studies in both the rent-seeking (Tullock 1993) and exploitation (Bowles and Gintis 2002) traditions show that access to common goods based on private resources and socio-economic inequalities decrease efficiency in the management of pools, contributing to their depletion (Bourguignon et al. 2007; Warner 2008). Thus, scholars investigate if redistributive policies that promote egalitarian distributions of physical capital and poor and able individuals' economic integration generate more wealth by allocating scarce resources more efficiently (Alesina and Rodrik 1994; Chiu and Khoo, 2005).

Objectives and hypotheses

Our basic objective is to assess if our approach to conceptualizing and measuring social capital can illuminate the debate on social capital's impact on human capital. Given the known positive relationship between society's stock of human capital and its wealth (Hanushek and Luque 2003), we expect our investigation to also contribute to clarify the relationship between social capital and efficiency. We seek to do it by investigating the role that the productivity of, and participation in, different forms of social capital, play in boosting 15-year old students' cognitive skills across OECD countries. Since we made these forms a function of the dispersion and level of socio-economic and cognitive resources in society, ours is ultimately an investigation about the impact of distributive policies on the acquisition of cognitive skills. Our overall hypothesis is that policies that pool and distribute resources of different types across individuals and groups in ways that allow their use as common, club and public goods should produce higher levels of human capital. Because we do not observe these policies or their effects directly, our overall hypothesis must be restated conservatively as simply expressing a positive association between human capital and distributions of resources within countries that allegedly foster social capital's productivity and higher participation in its returns.

Since social capital takes different forms, our overall hypothesis can be operationalized into four sets of sub-hypotheses each carrying a different subscript – O, S, C, or B – depending on the type of social capital associated with cognitive skills: overhead, support, control or bridging. In turn, each set includes a sub-hypothesis carrying the subscript 1 for the expected association between student's cognitive abilities and aggregate characteristic of the schools or countries where they study. These associations are meant to express social capital's productivity or contextual effects on cognitive abilities. The subscript 2 identifies sub-hypotheses about the association between cognitive abilities and participation in social capital's returns, i.e., about social capital's compositional effects on ability via individuals or group's resources. Hypotheses are complementary rather than alternative.

The first set of hypotheses pertains to social overheads capital. $H_{\mathbf{O1}}$ states that countries with higher per-capita wealth should display higher 15-year old students' average levels of cognitive abilities. Pooling supplies common goods unavailable privately that are critical to individuals. Policies promoting pooling at the system level use taxes, for example, to directly provide education, monitor students' achievements, or train teachers (Wößmann 2008). One explanation for these policies' apparently mixed results is that pooling is subject to declining productivities in larger groups as the costs of managing bigger pools rise while yielding positive externalities in small groups (clubs) (Wößmann 2000; Fuchs and Wößmann 2007). Thus, we expect the contextual effects of countries' wealth on ability to decrease or turn negative once controlled for schools' wealth. H_{O2} states that part of social overheads' contextual effects on ability should be compositional and capture the higher economic integration of students with richer family bakgrounds. Insofar as distributional policies increase efficiency and provide better opportunities to poor but able children to fulfill their capacities (for example, via vouchers for paying school fees, buy books, or get free school meals) we should expect more egalitarian countries to display higher levels of economic integration (Chiu and Khoo 2005). If this were the case, any negative correlation between country's economic inequality and abilities should weaken after controlling for students' family backgrounds and poor students' lower ability to participate in social overheads' returns in more unequal countries.

Regarding the association between support in bonding social capital and 15-year old students' cognitive abilities, H_{S1} hypothesizes that countries with higher cognitive homogeneity within schools should display higher average students' abilities. The evidence for within-school homogeneity's positive effects on ability is mixed (Hanushek et al 2003) but should become apparent after controlling for other types of social capital. In cognitively homogenous schools, teachers can target their pedagogical tools to average students rather than disperse their efforts across differently capable pupils (Dobbelsteen, Levin and Oosterbeek 2002). Furthermore, cognitively similar students support and learn from each other more easily (Hanushek and Wößmann 2006). Communication among equals boosts bonding social capital's productivity, facilitating learning. Cognitive homogeneity may be pursued indirectly with tracking policies promoting schools' functional stratification, as in systems separating schools by fields of study. Or it may be pursued directly with streaming policies that foster the creation of schools for students with special needs or talents. These policies are not very effective. The former are challenged by self-selection of students with similar economic backgrounds into alternative tracks. The latter tend to limit the benefits of participation into homogenous schools to students in the tails of the cognitive distribution (especially in the upper tail), undermining homogeneity in the middle (Hanushek and Wößmann 2006; Ariga and Brunello 2007). This introduces our second hypothesis, H_{S2}. It states that supporting social capital's contextual effects are partly compositional and result from human assimilation and its positive association with abilities; i.e., from talented children's higher opportunities to attend schools matching their higher abilities. This can be achieved, for example, through programs providing vouchers to talented children to attend special schools, thus promoting assimilation into the higher cognitive schemas taught there (Rivkin, Hanushek and Kain 2005). Insofar as cognitive abilities are partly genetically transmitted (Wößmann 2008) and can be partly predicted by parents' abilities, assimilation will manifest as (self-) selection of the children of the most capable into cognitively homogeneous school. Such selection effects may affect negatively system's overall efficiency, limiting the benefits of cognitive homogeneity to the most talented.

Regarding the association between bonding social capital of the control type and 15 year old students' cognitive abilities, H_{C1} expects countries with policies promoting socio-economic diversification within schools to show students' higher levels of abilities. Examples are affirmative action policies seeking to mix minority, migrant, or poor children with mainstream students via schools' admission policies or the granting of scholarships and vouchers to disadvantaged students. Insofar as within-school socio-economic heterogeneity' effects reflect bonding social capital's productivity, they should be contextual and stronger when social interactions between non-equals are more frequent. Differentiation creates a legitimate structure of rights and obligations where students can measure their status against each other. It promotes realistic aspirations that foster learning and discourage deviance (Dobbelsteen, Levin and Oosterbeek 2002; Entorf and Lauk 2008). H_{C2} states that students' ability to benefit from within-school socio-economic differentiation depends on their level of acculturation. As noted, acculturation is a process of status crystallization where norms and roles governing situational group members' inter-personal relations are learned. Acculturation distinguishes 'insiders' from 'outsiders' (van Ewijk and Sleegers 2010). Hence, migrant and other culturally disadvantaged children should find it more difficult to participate in socio-economically diversified schools. This lower participation may undermine socio-economic diversification unless thwarted by policies limiting between-school differences in students' backgrounds, as hypothesized next.

The final set of hypotheses pertains to the distribution across groups and use as public goods of socio-economic resources, i.e., to the association between bridging social capital and students' cognitive attainment. H_{B1} expects countries with more equal distributions of socio-economic resources across schools to display higher average levels of students' cognitive abilities. An egalitarian distribution of resources helps create public (less segregated) spaces of social interaction and reciprocation via students and teachers' exchanges or mobility and corresponding adjustments in educational provision (Karsten 2009; Montt 2011). Wider public spaces diversify students' resources, promoting learning. H_{B2} expects students to benefit from homogeneous school communities in inverse proportion to their reference groups' levels of segregation. Segregation is a function of local groups' low capacity to pool resources and benefit from common goods (Hayami 2009), and group members' poverty and destitution (Chesire 2007). Accordingly, we expect segregation to be less prevalent in countries with richer citizens and richer schools, and the positive effects of higher inclusion on abilities to explain part of the contextual effects of bridging social capital's productivity.

Data, variables and techniques of analysis

To test the hypotheses we use cross-sectional data from the 2006 Program for International Student Assessment (PISA), which estimated 15 year-old students' scientific, mathematical and reading abilities in 57 countries. To increase country comparability, we restrict the sample to OECD countries (except France and Australia, for which relevant data were missing). The working sample includes 178,253 students, 6,633 schools, and 28 countries. The data were weighted using normalized student weights, which correct for non-proportionalities in schools and individuals' selection within countries, while assigning equal weight to each (OECD 2007).

We benefit from data's hierarchical structure, which clusters students within schools and schools within countries, to perform a three-level analysis that estimates random-intercept effects on students' cognitive abilities (Snijders and Bosker, 1999). The dependent variable is 15-year old students' average plausible values in a 5-item test measuring knowledge and skills in science. Plausible values are imputations of students' unobservable latent science abilities, conditional on their observed scores on the 5-item test (Mislevy et al 1992). Each imputation is interpreted as a random draw from an empirically derived (posterior) distribution of science achievement built from students' observed scores, which has approximately the same distribution as the latent scale being captured (Wu 2005). Our analyses correct standard errors for the variability added by the imputations at the individual-level. For higher levels, we calculate robust standard errors that are less sensible to variance misspecification.

Three reasons justify restricting student's latent abilities to science. First, the 2006 PISA study emphasized scientific over mathematical and reading skills (OECD 2007). Second, our own analyses show that students' science performances capture well general abilities. Results from a factor analysis of students' scientific, reading and mathematical scores in 15 tests show that the former are the most highly correlated with the dimension capturing the largest percent of common variance (85%).1 Third, gender differences in science are smaller than in reading and mathematics (OECD 2006; Hyde and Mertz 2009) making it easier to generalize the results.

The independent variables measure students' physical, human and cultural resources, and the levels and dispersion of these resources in the schools they attend and the countries they live. At the individual level, we consider three variables recording students' economic integration, human assimilation and acculturation. The first measures students' economic and socio-cultural status (ESCS) with a composite index of family head's occupational status and education, and of household's classical culture consumption (OECD 2009). ESCS is a good proxy of families' wealth and students' levels of economic integration when these are poorly measured (Solon 2002), especially net of other resources.2 The second variable, number of books at home, aims to capture parents' and children's human capital and levels of assimilation (Wößmann 2000). The final variable, students' migrant status, captures student's cultural status and acculturation into society's mainstream norms (Hall and Farkas 2008).

[1] Results are available on request.

[2] PISA also makes available to researchers an index of family wealth. We opted for the ESCS index because it explains a larger proportion of variance net of all other variables. Results do not change much if either index is used.

A second set of independent variables measures the distribution of economic and human resources within schools. We take schools to represent situational and support groups (clubs). The level and dispersion of students' economic and cognitive resources within schools stand for school' levels of social overheads and bonding social capital. Students' average level of socio-economic status (ESCS) in the school measures the size of school's social overheads. We complement it with an indicator of school's private, semi-private or public ownership. Because schools recruit most students locally, we also take school's average ESCS status as indicating neighborhood's degree of segregation (higher the lower school's status). We capture the productivity of school's supporting social capital with two variables measuring how homogeneous 15-year old students' cognitive abilities are within the school. One is the Gini coefficient, in %, of students' performances in PISA's science tests in the school. The other indicates if the school applies selective admission. Finally, the productivity of linking social capital is measured with the Gini coefficient, in %, of students' ESCS in the school. Higher ESCS heterogeneity is interpreted as indicating higher levels of social control.

The final set of independent variables captures countries' wealth and how homogeneously distributed economic and human resources are between students and schools. We interpret variations in countries' wealth and economic inequalities to convey differences in their success at boosting the productivity of their social overheads and of bridging social capital. OECD's (2006) GDP per capita, in USA dollars at current prices and PPPs measures countries' social overheads. Countries' Gini index, in %, of between-school socio-economic heterogeneity measures the levels of bridging social capital. The remaining variables at the country level aim to capture the outcome of policies that promote economic integration, assimilation and acculturation by fostering economic equality across citizens, and schools' cognitive and functional differentiation. Country's Gini index of income inequalities (OECD 2009b) captures opportunities for able and disadvantaged citizens to become economically integrated and fulfill their potentialities. Country's number of distinct school programs measures the degree of functional differentiation of the educational system. Country's Gini index, in %, of between-school inequalities in students' performances in science tests measures how much countries stratify their educational system by abilities.

Table A1 in the appendix displays basic statistics for all variables.

Our analytical strategy reverses the order in which the independent variables have been presented. We start by analyzing the effects of country-level variables, continue with school-level variables, and finish with individual-level variables. In each case, we assess the impact of economic resources before human and social resources'. This stepwise model-building strategy helps infer correlations between the independent variables from changes in the direction and strength of their effects across models, and to assess if effects are compositional and linked to participation, or contextual and related to social capital's productivity.

Results

Table 1 displays multi-level model estimates for the impact on students' cognitive abilities of the distribution of economic and human resources in the 28 countries. The models control for, but do not aim to explain school and individual-level variability. Model 0, the empty model, decomposes the variance in students' tests across the three levels. The absolute and relative decompositions are shown in Table 1's middle and lower panels, respectively. Most of the variance in abilities (61%) stems from students' individual differences; about 30%, from school differences; and only 9%, from differences across countries. The intercept shows students' estimated mean score in science tests, 500 by construction. The country-level variables included in Models 1 to 4 explain 67% of between-countries variation.

Table 1. Effects of country-level variables on 15-year old students' performances in science. Estimates & standard errors. OECD Countries, PISA 2006[1]

Variables	Model 0 (empty)	Model 1	Model 2	Model 3	Model 4
Intercept	500.1**	500.2**	500.2**	500.1**	500.2**
	(5.9)[2]	(5.6)	(4.8)	(4.7)	(3.4)
GDP per capita		0.7*	0.1	0.0	-0.8*
		(0.6)	(0.4)	(0.5)	(75.6)
Gini coefficient of income distribution (entire population, in %)			-299.3*	-323.7*	-243.2*
			(97.7)	(122.2)	(86.5)
Between-schools inequalities in performance (Gini coefficient of schools' average performances, in %)				-1.3	0.7
				(3.8)	(1.9)
Types of school in the educational system (number)[3]				-1.6	-1.1
				(3.7)	(2.5)
Between-schools ESCS[4] inequalities (Gini coefficient of schools' average of 15-year old students' ESCS's, in %)					-11.0**
					(2.3)
First Level Variance *(students)*	6884.0	6884.0	6884.0	6884.0	6884.0
Second Level Variance *(schools)*	2835.4	2835.4	2835.5	2835.2	2835.7
Third Level Variance *(countries)*	948.1	867.8	630.7	614.3	311.7
Amount of variance attributable to students (within-school)	61%	0.0	0.0	0.0	0.0
% of within-schools variance explained		0%	0%	0%	0%
Amount of variance attributable to schools (between-school)	30%	0.0	-0.1	0.2	-0.3
% of between-schools variance explained		0%	0%	0%	0%
Amount of variance attributable to countries (between-countries)	9%	80.3	317.4	338.8	636.4
% of between-countries variance explained		8%	33%	35%	67%
% of total variance explained by all variables	0.0%	0.8%	3.0%	3.1%	6.0%

Notes:
Students' N = 178253; schools' N = 6633; countries' N = 28.
1 Data are weighted within countries but give the same weight to each of the 28 OECD countries used in the analyses (France and Australia excluded).
2 Robust standard errors
3 Considers any distinct educational programmes available to 15-year-olds
4 ESCS = Economic and Socio-Cultural Status

***** Significant at ≤ 0.05; ** significant ≤ 0.001

Model 1 assesses the association between country's 15-year-old students' average level of scientific abilities and the overall productivity of its social overheads, as measured by country's per-capita GDP. It is positive and significant in model 1, approaches 0 in model 2 after controlling for income inequalities in the country, and turns negative and significant in model 4 after controlling for socio-economic inequalities between schools. The positive effect attributed to wealth in model 1 was due to richer countries having more egalitarian wealth distributions and the positive association between economic equality and cognitive abilities. Insofar as country's wealth stands for higher educational investments, the results tentatively confirm H_{O1} expectation that pooling is subject to declining marginal returns as pool's size increases. Until school and individual level variables are considered we cannot settle the extent to which these negative effects reflecting common goods' diseconomies of scale are over-compensated by richer countries' higher probability to have richer schools and benefit from these smaller pools, net of richer school's higher probability to be attended by richer students.

Model 2 shows that in economically unequal countries students display lower cognitive abilities. Almost 1/3 of income inequalities' negative effect on abilities is attributable to unequal countries having lower bridging social capital, as measured by between-school socio-economic inequalities (see change for income inequalities estimate in model 2 after controlling for between-school ESCS inequalities in model 4). We hypothesized above that the remaining negative effects could be due to countries' low levels of economic integration and that they should disappear after controlling for schools' and students' wealth. Pending the confirmation of this mechanism, we tentatively accept H_{O2} that countries that distribute wealth more equally among their citizens show higher 15-year old students' cognitive abilities, despite equality being correlated with country's wealth (overheads) and this being negatively associated with abilities[3].

Model 3 estimates the association between cognitive abilities and the result of educational policies aimed at redistributing students across schools according to cognitive and functional criteria. The more country's schools differ cognitively or functionally (in system's number of distinct educational programs), the lower students' cognitive attainments are. Yet, the estimates are insignificant. Pending more definitive tests, we conclude that streaming and tracking do not significantly affect bonding social capital's productivity. If sorting policies had such effects, they should operate at the school level, via mechanisms of selection and self-selection of students with alternative cognitive abilities and cultural standings into cognitively homogeneous and socio-economically heterogeneous schools. We assess these possibilities further below.

Model 4 shows that between-school socio-economic heterogeneity is negative and significantly associated with abilities. This tentatively confirms H_{B1} that countries that have schools which differ markedly in the socio-economic composition of their student

[3] The proportion of variance in abilities due to equality is 4 times larger than the one due to wealth.

bodies display lower results in cognitive test. We tentatively interpret this effect as reflecting the fewer bridges that these countries have between schools and the neighborhoods where they are located, bridges through which reciprocal exchanges of information, technology, and skills relevant to the acquisition of cognitive abilities flow more freely. However, low bridging social capital's negative externalities could be partly due, as hypothesized in H_{C1}, to the negative impact of within-school socio-economic homogeneity – of low bonding social capital of the control type. A more definitive conclusion can be drawn only after considering school and individual-level variables, which is done in Table 2.

Table 2. Effects of country, school, and individual-level variables on 15-year old students' performances in science. Estimates and standard errors. OECD Countries, PISA 2006

Variables	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Intercept	500.2**	494.7**	494.7**	496.3**	493.1**	492.9**	494.0**	495.4**	496.8**
	(3.4)	(2.9)	(3.0)	(2.7)	(3.6)	(3.5)	(3.4)	(3.2)	(3.2)
GDP per capita	-0.8*	-1.2**	-1.2*	-0.9*	-0.9*	-0.9*	-0.9*	-0.8*	-0.7*
	(75.6)	(0.3)	(0.3)	(0.3)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)
Gini coefficient of income distribution (population, in %)	-243.2*	24.8	41.5	32.7	26.8	27.6	32.7	42.9	41.7
	(86.5)	(101.3)	(101.5)	(83.9)	(85.6)	(86.8)	(86.7)	(73.1)	(73.1)
Between-schools inequalities in performance (Gini coefficient of schools' average performances, in %)	0.7	-0.7	-0.4	-0.5	-0.7	-0.7	-0.8	-0.9	-0.9
	(1.9)	(2.8)	(2.9)	(2.0)	(1.9)	(1.9)	(1.9)	(1.8)	(1.7)
Types of school in the educational system (number)	-1.1	4.2	3.9	-0.2	-0.6	-0.7	-0.9	-0.2	0.0
	(2.5)	(2.8)	(2.9)	(2.5)	(2.4)	(2.4)	(2.3)	(2.2)	(2.3)
Between-schools ESCS[4] inequalities (Gini coefficient of schools' average of 15-year old students' ESCS, in %)	-11.0**	-7.0*	-7.1*	-8.3**	-8.3**	-8.1**	-8.2**	-8.1**	-8.1**
	(2.3)	(2.3)	(1.9)	(1.9)	(1.8)	(1.9)	(1.9)	(1.7)	(1.8)
School ESCS		69.1**	70.6**	60.2**	59.6**	59.1**	39.0**	36.7**	36.9**
		(8.5)	(8.8)	(7.4)	(7.4)	(7.2)	(7.2)	(6.5)	(6.4)
School privately owned			-14.9**	-14.2**	-14.8**	-13.9**	-16.3**	-16.3**	-15.8**
			(3.0)	(2.8)	(2.8)	(2.9)	(2.7)	(2.7)	(2.7)
School semi-privately owned			3.3	3.1	2.6	2.8	1.7	0.9	0.8
			(4.9)	(4.7)	(4.9)	(2.2)	(2.1)	(2.1)	(2.1)
Within-schools inequalities in performance (Gini coefficient of students' performance distribution in school, in %)				-8.6**	-8.5**	-8.7**	-8.7**	-8.3**	-7.8**
				(1.2)	(1.2)	(1.1)	(1.0)	(0.9)	(0.9)
School has selection ability criteria of admission					5.8*	5.8*	5.4*	5.4*	5.5*
					(3.1)	(3.1)	(3.0)	(2.9)	(2.9)
Within-schools ESCS inequalities (Gini coefficient of students' ESCS distribution in school, in %)						14.1*	12.1*	15.1*	12.9*
						(5.9)	(5.7)	(5.6)	(5.5)
Student socioeconomic and cultural status							21.6**	13.6**	13.2**
							(2.0)	(2.0)	(2.0)
Books at home (number)								11.9**	11.6**
								(1.2)	(1.2)
Immigration status									-28.6**
									(4.2)
First level variance *(students) (σ^2)*	6884.0	6881.4	6881.3	6882.6	6882.2	6881.9	6564.1	5475.5	5448.6
Second level variance *(schools) (τ_{01})*	2835.7	1572.7	1564.4	1299.5	1295.9	1296.1	1202.5	1119.7	1107.3
Third level variance *(countries) (τ_{02})*	311.7	246.4	251.1	209.9	208.6	207.5	194.3	176.9	185.7
Amount of variance attributable to students	0.0	2.6	2.7	1.4	1.8	2.1	319.9	1408.5	1435.4
% of within-schools variance explained	0%	0%	0%	0%	0%	0%	5%	20%	21%
Amount of variance attributable to schools	-0.3	1262.7	1271.0	1535.9	1539.5	1539.3	1632.8	1715.9	1728.3
% of between-schools variance explained	0%	45%	45%	54%	54%	54%	58%	61%	61%
Amount of variance attributable to countries	636.4	701.7	697.0	738.2	739.5	740.6	753.8	771.2	762.4
% of between-countries variance explained	67%	74%	74%	78%	78%	78%	80%	81%	80%
% of total variance explained by all variables	6.0%	18.4%	18.5%	21.3%	21.4%	21.4%	25.4%	36.5%	36.8%

Table 2 adds school-level (mid panel) and student-level (lower panel) variables to the country-level variables introduced in model 4 of Table 1, which is reproduced in the first column of Table 2. Models 5 and 6 add variables pertaining to school's physical resources; models 7 and 8, to school's human resources; and model 9, to school's social resources. Model 10 adds students' socio-economic statuses (ESCS); model 11, number of books at home; and model 12, students' migrant statuses. School level variables explain about 61% of between-school variance; student-level variables, about 21% of within-school variance.

Model 5 in Table 2 estimates the effect of students' average ESCS in the school on abilities, net of country effects. It is positive and significant. As expected, students in wealthier schools, as measured by students' average ESCS, perform higher in science tests. The declining marginal returns to educational investments (negative effects of pooling) detected at the country level worsen in model 5, supporting the argument that common goods' inefficiencies occur in large aggregates. The positive effects of schools' social overheads (small groups' pooling) remain significant also after controlling for students' personal ESCS's in model 10, but considerably weakened (the coefficient for school's ESCS drops nearly 1/2 relative to model 5). The results confirm H_{O1} that social overheads have positive externalities on cognitive attainment, with declining marginal utilities as groups' size increases. As hypothesized in H_{O2} part of the effects of social overheads' productivity are due to richer countries having richer schools and these having richer students, i.e., to richer countries' having higher numbers of economically integrated students. Also as expected, economic integration is higher in countries with more egalitarian income distributions. The association is strong: The negative effects of income inequalities on cognitive abilities vanish after discounting the wealth of country's schools and families. We ignore if wealth promotes sharing or if redistribution fosters affluence by allocating scarce results more efficiently, but we can corroborate that more equal societies display higher levels of economic integration.

Model 6 adds a second indicator of school's material resources based on whether it is privately or semi-privately owned (baseline: publicly owned). Net of private schools' tendency to be attended by better-off students and enjoy larger overheads, the association between private ownership and students' abilities is significantly negative (semi-private schools' effect is insignificant). Private schools' negative association with students' abilities is partly due to socio-economically advantaged students' self-selection into private schools and to within-school socio-economic homogeneity's negative effect on learning (see change in private ownership's coefficient in model 9 relative to model 6). But it also reflects the negative impact that private schools' higher heterogeneity in students' abilities has on learning, despite private schools using selective admission more frequently (see changes in private ownership's coefficient in models 7 and 8). This higher heterogeneity may be endogenous and reflect richer and less able students' choices of private schools to improve performance, apparently with meagre results. In sum, private school students' below-average performances are attributable to their benefiting less from the positive externalities of cognitively homogenous and socio-economically heterogeneous schools (of bonding social capital's productivity).

Models 7 and 8 show that, indeed, cognitively homogenous schools display higher average levels of students' abilities. Model 7 shows that schools attended by students with heterogeneous cognitive abilities perform significantly worse than other schools. Model 8 shows that the effect is partly due to schools with cognitively heterogeneous students applying fewer selection filters, and these filters having positive effects on performance. The effect of within-school cognitive heterogeneity would be more negative were not because it is partly suppressed by the positive effects that these schools' higher than average socio-economic heterogeneity have on performance.[4] Thus, any policies or sorting mechanisms that generate cognitively homogenous schools will also contribute to raise students' cognitive standards. Above, we interpreted within-school cognitive homogeneity's contextual effects to be capturing the productivity of bonds of mutual support and of shared understandings. These contextual effects decrease after controlling for student's personal abilities (measured with number of books at home) and migrant statuses in models 11 and 12, but remain positive and significant. While highly talented students and natives self-select or are selected into cognitively homogeneous schools more often than lowly or mid-talented students and migrants, their higher levels of assimilation explain only part of cognitive homogeneity's contextual effects (see changes in the coefficients for within-school inequalities in performance and selective admission criteria in models 11 and 12 relative to models 9 and 10). The results confirm $H_{\mathbf{S1}}$: students benefit from attending cognitively homogeneous schools. $H_{\mathbf{S2}}$ is also confirmed: students who are more highly assimilated (e.g., who have more books at home or are more language proficient) are more likely to benefit from the strong bonds of mutual support available in such schools.

Model 9 adds an indicator of within-school socio-economic inequalities: the higher the heterogeneity of students' socio-economic backgrounds in the school, the higher students' cognitive performances in science tests. This association is not simply due to socio-economically differentiated schools being attended by students better acculturated into the normative frames that facilitate effective learning. The effect of within-school socio-economic differentiation remains significant and positive even after controlling for individual level characteristics like migrant status in models 10 to 12. The results confirm $H_{\mathbf{C1}}$ on the positive externalities of control in situational groups, higher in more socio-economically heterogeneous schools. Differentiation, we argued, allows students to calibrate their status against fellow peers', fostering realistic aspirations, group cohesion and learning. The results also confirm $H_{\mathbf{C2}}$ or the role played by acculturation in explaining who participates more fully in linking social capital: upper status and native students (see changes in the coefficient for school's ESCS heterogeneity after adding students' socio-economic and migrant status in models 10 and 12). They also show that more talented students (with more books at home) are less likely to attend economically diverse schools, possibly because socio-economic homogeneity is a by-product of talented students' higher assimilation into cognitively homogeneous schools.

[4] See change in the effect of school's cognitive heterogeneity after controlling for students' socio-economic backgrounds in Model 9.

As expected, ESCS heterogeneity between schools is negatively correlated with ESCS heterogeneity within schools. However, the correlation is weak (compare estimates in models 8 and 9), hardly affecting the contextual effects of between-school socio-economic inequalities on abilities. In contrast, the correlation between social inclusion and between-school socio-economic inequalities is strong (see change in the coefficient for between-school ESCS inequalities in models 5 relative to model 4), confirming that wealthier schools proliferate in countries with more socio-economically homogeneous schools. The negative effect of between-school socio-economic inequalities on abilities remains significant even after discounting this association. The results confirm both H_{B1} and $H_{\mathbf{B2}}$. Countries with fewer differences across schools in student's socio-economic backgrounds, i.e., with higher bridging social capital, attain better cognitive results. Higher status schools are more likely to participate in the benefits provided by these richer systems of interrelated schools.

Summary and conclusions

This paper reviewed the concept of social capital and highlighted its four main uses. There is, first, bridging social capital, understood as generalized trust stemming from bridges connecting distinct groups. The function of trust is to foster reciprocity, laying the foundations of civic society. Second, there is bonding social capital connecting people through strong ties. Strong ties may express relations of mutual support and understanding among equals sharing the same cognitive system. Or they may consist of normative relations of control in status systems characteristic of situational groups, which help members calibrate each other's worth. Each performs a different function, support or control, giving rise to two types of bonding social capital. Finally, there is social overheads capital, which accrues benefits to groups via sharing of common pools of physical resources.

Social capital's different functions derive from its operating as a public, club, or common good. Bridging social capital is a public good; bonding social capital, a club good; and social overheads capital, a common good. Consequently, each must be measured at different levels. The public nature of bridging social capital requires measuring it at the community/societal level. The relations of mutual support and control developing within clubs must be grasped at the group level. Finally, social overheads capital must be measured both at the community and the group levels to capture the positive externalities of common-goods and the diminishing returns to pooling in larger groups.

This conceptualization helped us devise appropriate indicators for measuring social capital' many functions. We distinguished between measures that grasp social capital's productivity (the contextual effects pertaining to its relational aspects) and measures that capture individuals' participation in social capital's returns. We argued that existing measures focus largely on participation, due to difficulties in measuring relational aspects. In contrast, we proposed simple indicators that take advantage of the inter-correlations between physical, cognitive and social capital to measure both aspects. We proposed to focus on the dispersion and level of physical and cognitive resources across community's groups and members to measure social capital's productivity and participation in its returns.

We proposed to capture the productivity of bridging social capital with measures of the degree of socio-economic inequalities among groups, arguing that equality of physical resources nurtures reciprocity between groups. To measure the productivity of supporting bonding social capital we proposed to calculate group's cognitive homogeneity, arguing that it reflects shared understandings on which mutual support thrives. To measure the productivity of linking (control) social capital, we suggested calculating groups' internal socio-economic heterogeneity, on the grounds that heterogeneity helps members recognize the rights and duties of each other's statuses and raise legitimate expectations. Finally, we proposed to capture the productivity of social overheads capital by measuring the stocks of physical resources pooled by group and community members.

To assess participation in bridging social capital we proposed using a collective index of social inclusion based on the socio-economic resources of the group to which an individual belongs. We argued that accessibility to bonding social capital of the support type depends on individuals' assimilation into group's cognitive framework, as measured by individuals' cognitive skills. Similarly, accessibility to bonding social capital of the control type depends on individuals' acculturation into group's normative framework, as measured by individuals' legal/cultural status. Finally, we proposed to assess accessibility to common goods with measures of individuals' material resources.

We next applied our conceptual framework to assessing the relationship between social and human capital. Using multilevel models appropriate for estimating effects of variables measured at three levels of aggregation, we assessed the association of different forms of social capital and participation with cognitive abilities in science among 15-year-old students in 28 OECD countries, using PISA's 2006 study. We hypothesized that countries which distribute physical, cognitive, and cultural resources in ways that increase the productivity of social capital and foster participation in its returns should present higher levels of students' cognitive abilities.

The results confirmed the hypothesis. First, participation in the returns of all types of social capital plays a significant role in students' acquisition of cognitive abilities. Countries where there are more 15-year-old students economically integrated, humanly assimilated, normatively acculturated, and socially desegregated show higher average levels of students' cognitive abilities. This is not only because economic, human and cultural capital are positively associated with abilities, but also because these resources facilitate participation in social capital's returns. These returns are contextual and occur mostly independently of individuals' participation in them. They express the productivity of social capital in its different forms. High productivities of bridging social capital, of support and control forms of bonding social capital, and of social overhead capital (as measured, respectively, by between-school socio-economic homogeneity, within-school cognitive homogeneity, within-school socio-economic heterogeneity, and wealthy schools), are all associated with higher abilities.

Important conclusions ensue from these results. First, social capital's productivity must be clearly distinguished from participation in its returns. The former is a factor of production while participation is an indicator of accessibility to capital. Both explain cognitive attainment but participation does it indirectly, via compositional effects attached to individuals' resources. In contrast, social capital's role is direct, via contextual effects springing from the positive externalities of social relations. Second, social capital is multi-dimensional. There is not one social capital but several. Some of its forms stem from relations between groups (bridging social capital); others, from relations within groups (bonding social capital); and still others, from both (social overheads capital). Third, to measure each form it helps to consider which distribution of physical and cognitive resources between or within groups best promotes relations of reciprocity, support, control, and pooling. Fourth, while each form is unique and independently correlated with cognitive ability, they are all interrelated. For example, we found that bridging social capital is negatively associated with bonding social capital of the control type (socio-economic heterogeneity between groups is accompanied by socio-economic homogeneity within groups) while the latter is positively associated with bonding social capital of the support kind (socio-economic homogeneity tends to accompany cognitive heterogeneity within groups). This poses difficult dilemmas for policy-makers worth being explored in the future regarding choices of redistributive policies and their possible contradictory effects. Our results are promising but more work is needed to assess if our conceptual and measuring approach to social capital also works for other outcomes (e.g., income, wealth, status), for other clubs (e.g., firms, towns, neighbourhoods), and for other communities (markets, regions, cities, etc.).

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APPENDIX

Table A1. Descriptive statistics

Variables names level 1 (individuals)	N	Mean	SD	Minimum	Maximum
Plausible values in science test 1	178253	495.87	100.38	76.59	887.19
Plausible values in science test 2	178253	495.09	100.43	23.44	923.28
Plausible values in science test 3	178253	495.92	100.28	75.01	897.92
Plausible values in science test 4	178253	495.89	100.46	71.93	863.60
Plausible values in science test 5	178253	495.95	100.34	22.79	873.02
Family's ESCS	178253	-0.08	1.06	-5.67	3.35
Books at home	178253	3.28	1.45	1.00	6.00
Migrant Status	178253	0.04	0.20	0.00	1.00

Variables names level 2 (schools)	N	Mean	SD	Minimum	Maximum
School ESCS	6633	-0.10	0.71	-3.13	1.75
School privately owned	6633	0.05	0.21	0.00	1.00
School semi-privately owned	6633	0.09	0.28	0.00	1.00
Within-school inequalities in performance	6633	8.22	2.31	0.00	20.50
School selects by ability	6633	0.60	0.49	0.00	1.00
Within-schools ESCS inequalities	6633	55.25	10.85	0.00	83.80

Variables names level 3 (countries)	N	Mean	SD	Minimum	Maximum
GDP per capita	28	31.63	12.88	12.07	75.75
Gini index of Income Inequalities	28	31.23	5.68	23.00	47.00
Between-schools inequalities in performance	28	12.97	1.85	9.50	16.60
Number of Types of School	28	2.57	1.45	1.00	5.00
Between-schools ESCS inequalities	28	8.49	2.03	5.80	13.50