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Improving Excellence in Schools: Evidence from the Italian OECD-PISA 2012 Data

*Brunella Fiore**

Author information

*Department of Sociology and Social Research, University of Milano-Bicocca, Italy.

Contact authors' email address

*brunella.fiore@unimib.it

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Improving Excellence in Schools: Evidence from the Italian OECD-PISA 2012 Data

Brunella Fiore[*]

Abstract: This paper investigates the characteristics of excellence in schools' performance. The main objective is to highlight the characteristics of students and schools that seem to favour (or decrease) the probability of being top-performers in the mathematical literacy. In order to achieve these objectives, logistic regression models have been developed based on the OECD-PISA 2012 data of the Italian sample. The first analysis focuses on top-performers; the second analysis focuses on the characteristics of resilient top-performers and the third analysis focuses on the advantaged top-performers. The main results indicate strong differences in the Italian macro-areas: North-West and North-East obtain better results than the regions of the South in improving excellence. This is particularly true if the student comes from a family disadvantaged context. A second result is that there is a gender issue in excellence, which, if addressed, could significantly raise the percentage of top-performers across the country. The keys to addressing the gender difference include the following: to foster motivation of girls (and students in general) on mathematics, to orient students towards the choice of mathematically strong paths in the phase immediately before adolescence (when gender stereotyping in mathematics is activated).

Keywords: top-performers, improving excellence activities, resilience, gender

[*]Department of Sociology and Social Research, University of Milano-Bicocca, Italy. E-mail: brunella.fiore@unimib.it

Introduction

In the PISA (Programme for International Student Assessment) from OECD (Organisation for Economic Co-operation and Development), Italy is characterised by good guarantees of fairness toward students. At the same time, the percentage of so-called 'top –performers' on mathematics - those who reach the level of 'excellence' in the performance (Level 5 and Level 6 of the PISA mathematical scale) - is very small. In Italy, only in recent years, the promotion of excellence has entered the agenda of educational policies. Studies on education have traditionally focused on inequalities in terms of 'no left behind' students with low performance and low cultural and socio-economic status of the family of origin (Wang, Lu, Li & Zheng, 2011; Longobardi & Agasisti, 2012). The focus almost exclusively on the 'disadvantaged' and the lack of attention on top-performers, however, could be a boomerang: focus on the best resources of human capital is in fact a strategy to overcome the crisis in which the economies, especially in Europe, seem to harness; therefore, neglecting the excellence means not taking advantage of significant growth opportunities. The recent economic literature highlights the strategic role of human capital as the main element of economic growth in each country. More specifically, many studies have shown that the performance of the students recognised on the internationally standardised accountability of the education systems constitutes the proxy of the quality and quantity of human capital (Pennisi, 2010). In Italian educational policies, the promotion of excellence is mentioned for the first time in the Italian Law of 11 January 2007, where Article 2, subsection D shows: "Fostering the excellence of the students obtained in various modalities in the educational paths of the students[1]". Today the excellence links is to higher education while for primary and secondary education this aspect is still not contemplated. To date, this indication of the law was translated by Ministerial Directive on July 30, 2013 into only financial resources: 2/3 of the funding for students graduating in the school year 2013/2014 with a score of "100 with laude" and 1/3 of the funding for students who won

[1] Law 1/2007, Art.2 Sub.D.
http://archivio.pubblica.istruzione.it/dg_ordinamenti/allegati/legge1_07.pdf

competitions in specific disciplines (i.e., scientific-technological, logical-mathematical, literary, historical-social-philosophical, arts and professions). The project VALES (School Evaluation and Development)[2] in the national schools evaluation's system, promoted by INVALSI (National Institute for the Evaluation of the Educational System), introduces some elements of reflection for schools on empowerment of students skills and performances. External observers have noted this area as overlooked in the daily practice of teaching (as an example: assignment of different tasks in class or identification of areas on which to upgrade) (VALES, 2014). Differently, the activities related to strengthening extracurricular competitions in various disciplines are now regularly proposed to students by their schools (VALES, 2014).

The article focuses on PISA data. PISA is a comprehensive and rigorous international programme promoted to assess student performance and to collect data on students, families and institutional factors that could help explain differences in performances. In particular, information coming from this survey focuses on how well students are prepared to meet the challenges of life (Fiore & Romeo, 2013) rather than to examine how well they perform a particular curricula specified by the school system. This survey collects information about the reading, mathematics and science results of 15-year-old students. It takes places every three years with a different major subject area. Mathematics represents the focus for the survey conducted in 2003 and for the one conducted in 2012. Reading represents the focus in the surveys of 2000 and 2009. In 2006 and 2015 the focus is on science. In each survey several subscale are considered. In this article the Pisa 2012 data, focused on mathematics, has been taken into account. In PISA 2012 several mathematical subscales are proposed: three scales are on processes (formulating, employing and interpreting); and four scales are on the content (change and relationships, space and shape, quantity and uncertainty and data). Given the high correlation between the general scale and subscales (OECD, 2014b), only the general scale is here considered.

PISA analyses something different from school's curricular path. It investigates the expertise required to demonstrate the ability to use the knowledge to move into the real world. In addition, PISA integrates various

[2] Link: VALES School Evaluation and developments: http://www.invalsi.it/invalsi/ri/vales/

instruments of educational assessment and it is constantly looking for assessment tools able to overcome the traditional limits recognised in accountability. For this reason, different types of questions are proposed in the PISA tests: open-ended questions, open-answer correspondence, and simple and complex closed-answer responses. Furthermore, standardised assessment is a practice more and more accepted, also for PISA and the Italian ten-year national assessment system contribute[3]. The increased reduction in the levels of cheating into the national large scale assessment on student learning (INVALSI, 2014a) could be interpreted as an indicator of the increasing acceptance of the standardised educational external examination. Particularly, this paper examines the factors associated with excellent performance (top-performing)[4], with particular attention to the cultural and socio-economic backgrounds of the families of students, the Italian macro-area from where students come from and their gender. Many studies have revealed the association between students' learning at school and the cultural and socio-economic status of their family of origin (Coleman *et al*., 1966; OECD, 2010). Much less is known about the factors that help disadvantaged students express their full potential and 'beat the odds' of failure. This refers to the ability to exceed expectations and to excel in performances in spite of the disadvantaged cultural socio-economic and cultural status. The goal then becomes to understand how to help students overcome the likelihood of modest performance in the face of the cultural and socio-economic status. Even low attention is given in the literature regarding education for students who come from an advantaged context and perform high (Martini, 2005): to what extent do these students achieve excellence? In a reversal of perspective: what factors lead students who have all it takes to make it from the point of view of cultural and socio-economic backgrounds to not achieve excellence? What are the individual characteristics supporting students in resilience and, ultimately, in excellence? What are the characteristics of schools that can facilitate the achievement of excellence? In the last ten years the accountability systems on education as OECD-PISA, IEA-TIMSS[5] have revealed the deep

[3] For more information see Invalsi Press Release http://www.invalsi.it/invalsi/areastampa.php?page=index

[4] In this work, excellence and top-performing are interchangeable definitions.

[5] IEA International Association of Evaluation of Educational Achievement
TIMSS Trends in International Mathematics and Science Study

differences in performances of student coming from different macro-areas of Italy. Those differences are translated into disparities of life opportunities for students living in the different regions of the country (Bratti, Checchi & Filippin 2007; Palmerio & Montanaro, 2012): in particular, the regions from the North show higher performance and higher percentage of top-performer students than regions from the South. Considering the cultural and socio-economic status of each Italian region, what is the extent to which each of them is able to make its students top-performers? Are the regions that have more student top-performers also those that show the greatest disparities and leave behind a larger number of students? The literature on top-performers shows that there are huge differences about how girls and boys perform in excellence: boys show higher results compared to girls. In the literature, the better result for boys is not new: among students with higher expertise, boys have much better performances than girls (Leahey & Guo, 2001; Caplan & Caplan, 2005; Halpern & Saw Wai, 2005; Mills, Ablard & Stumpf, 1993; Benbow & Stanley, 1982). Before the age of 12, girls show better performance in tests that require computing skills. After age 12, this advantage is reversed: looking at the highest performance, boys show better performances compared to girls (Hyde, J.S., & Jaffee, S. 1998; Robinson et al., 1996). To what extent this differences between boys and girls are present? Where resilient girls are more and to which characteristics they find their best? And what about advantaged top-performer girls?

Hypotheses

Considering both the theoretical framework and the empirical evidence on excellence and performance, we expect to find evidence that students, and in particular students coming from different areas of Italy and of different gender, reach excellence differently according to the social position of students. We choose to test this hypothesis using one of the most important indicators of social position at our disposal: family cultural and socio-economic background. Therefore, this research aims to test the following hypotheses.

Hypothesis 1

Students coming from families with higher cultural and socio-economic status gain more chance to be top-performer students than their less privileged counterparts. Students from the most advantaged families possess higher digital skills and, in general, have more cultural, economic and social resources at home (Willms, 2003). Following the argument of the knowledge gap, we expect to find that students coming from advantaged families show higher probabilities to be top-performers.

Hypothesis 2

Students coming from regions with the lower socio-economic status of their students show lower probabilities that they should be top-performers. In particular in disadvantaged regions from South and South and Island students coming from lower socio-economic status show lower chance to be top-performers compared to students from lower status living in the North Area. The analysis will be done on top-performer students the socio-economic status of each region. The hypothesis is that as for the more general result on performance highlighted by both PISA and INVALSI tests showing best results in the North Area, regions in the South could have more difficulties in having higher percentage of top-performers compared to those belonging to North (INVALSI, 2014b). Furthermore, the hypothesis is that disadvantaged regions show more difficulties in promoting their resilient students to excellent result.

Hypothesis 3

According with literature, we expect to find that the chance to be top-performer for girls is lower than for boys. Furthermore we expect to find a larger gender gap within resilient top-performers compared to advantaged top-performer boys and girls. The hypothesis is that competition and pressure on good results could be higher where the percentage of top-performers is higher and in this way in lyceum and in regions with higher percentage of top-performer students. Girls could suffer the competition (expressed by indicator as higher level of anxiety and lower level of self mathematical concept) and consequently performing worse than boys. Furthermore, the hypothesis is that anxiety level should be higher for girls coming from disadvantaged context because family should offers less skill to overcome the stereotype affecting the relation on 'gender and mathematics'. In this way we expect to find, within the group of resilient, less resilient girls top-performers compared to boys.

Sample and method

Analysis was developed considering the complex sampling design. Students were sampled through a two-stage sampling technique, and students and schools were weighted in inverse proportion to their probability of being sampled. In particular, schools were sampled in proportion to the number of their students, and students sampled with equal probability within the sampled school. In the analyses and computational process it was necessary to consider the particular structure of the PISA dataset which covers the five plausible values (PVs) for parameter estimation and the replicates for standard error estimation. The PVs are meant to prevent biased inferences, which can occur as a result of measuring student skill, which is not directly observable. Instead of directly estimation a probability distribution is estimated. Then the PVs are drawn randomly from this distribution. The required statistic and its respective standard error have to be computed for each plausible value and then added together (OECD 2012a). Given the PISA's complex sample design, the use of replicates is needed to obtain reliable sampling variances. These methods work by generating several subsamples (replicates) from the whole sample. The statistic of interest is then estimated for each of these replicates and then compared with the whole sample estimate to provide an estimation of the sampling variance. PISA uses the Fay's variant of the balanced repeated replication (BRR) (OECD, 2012a). The analysis was supported by IBM SPSS statistics (Statistical analysis system) program; SPSS macros from OECD (2009) were exploited.

The top-performing students' characteristics

Pisa defines equity in education as the ability to provide students, regardless of gender, cultural and socio-economic status, with opportunities to access quality educational resources and to learn (OECD, 2010). As shown in Figure 1 Italy is among those countries ensuring more equity between regarding performance and the chance to ensure situations of fairness. Regions such as Veneto, Friuli Venetia Giulia and Trento show OECD above average performance and a good level of equity. Regions such as Calabria, Sicily, Sardinia and Calabria definitely show OECD below average performance in the face of a modest level of equity. Which characteristics differ between the Italian national context and, in general, its regions? What features assume the equity as shown in the graph in Figure 1? Countries such as Singapore and Korea seem to be more able to guarantee fairness among students than does Italy but, by contrast, these countries have higher percentages of students with very high performances (Figure 1). There are also very virtuous countries that provide very high levels of excellence and at the same time guarantee a good fairness in terms of performance. This is the case for Hong Kong-China and Macao-China. If the good news for Italy is to enjoy fair conditions compared to other countries participating in the OECD-PISA, it is also worth noting that this equity is especially given by the homogeneity in performance. Basically, equity is provided by a levelling-down approach, where all students perform similarly. The absence or scarcity of students in extreme levels of excellence leads to a homogenisation of students in similar conditions. This reflects a greater equity (Martini, 2005). Five editions of the OECD PISA surveys show that the proportion of students at mathematical Level 1 and 0 was significantly reduced in the last 10 years (INVALSI 2014b)[6]. It is not possible to observe the extent to which individual Italian regions contributed to the reduction since the regional sampling[7] is only for the 2009 and 2012 editions[8.]

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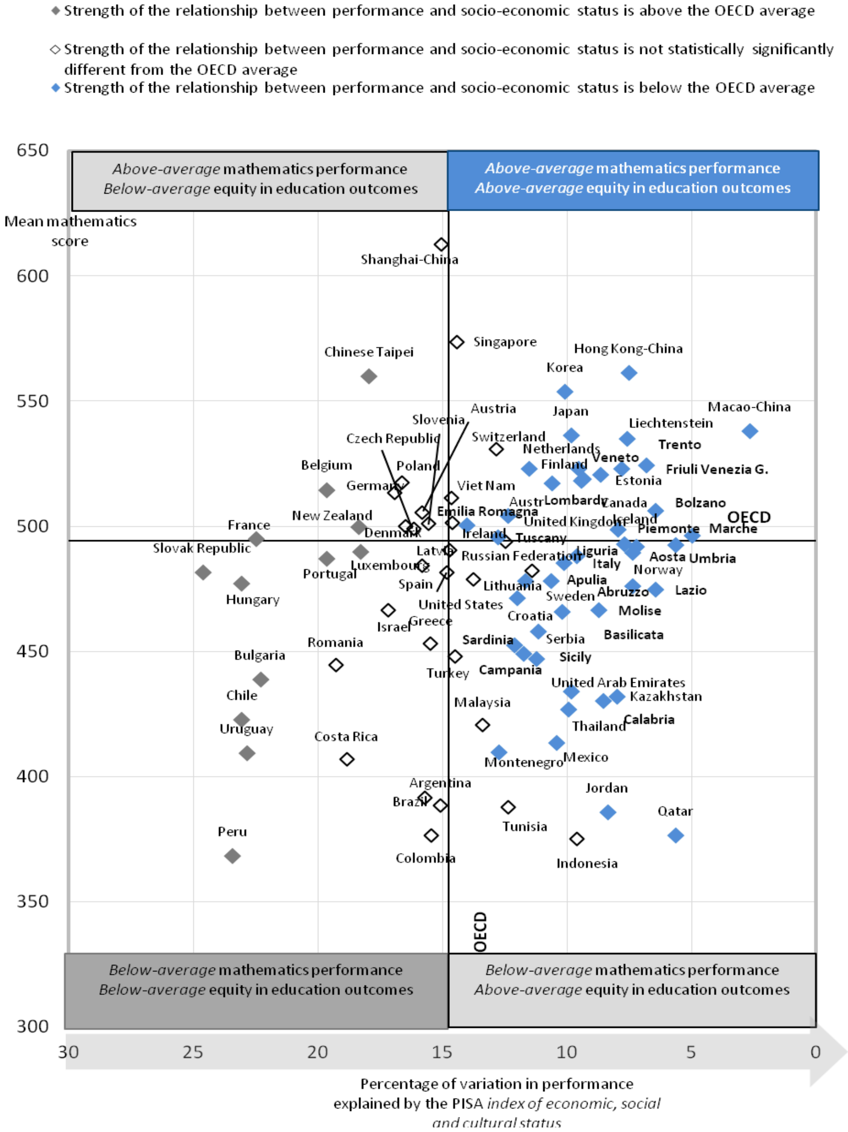
[6] At Level 1 are students performing less than 420 points and at Level 0 are students performing less than 358 points. "At Level 1, students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are almost always obvious and follow immediately from the given stimuli." (OECD, 2014, p. 61) Individuals with proficiency within the range of Level 1 are likely to be able to complete Level 1 tasks, but are unlikely to be able to complete tasks at higher levels. It have to be noticed that Level 0 was introduced from the 2003 edition in order to better identify the large proportion of student not reaching Level 2.

[7] An oversampling was done into four regions in 2003 (Lombardy, Piedmont, Tuscany, Veneto) and 2 provinces (Trento and Bolzano). The edition of PISA 2006 saw a regional sample in 11 different regions: Apulia, Basilicata, Campania, Emilia Romagna, Friuli Venetia Giulia, Liguria, Piedmont, Lombardy, Veneto, Sardinia, Sicily and 2 provinces: Trento and Bolzano.

[8] PISA 2012 will be the last edition with sub-regional sampling. From now on, the focus shifts on the INVALSI surveys, pursuing the same goal of transparency in levels of learning achieved.

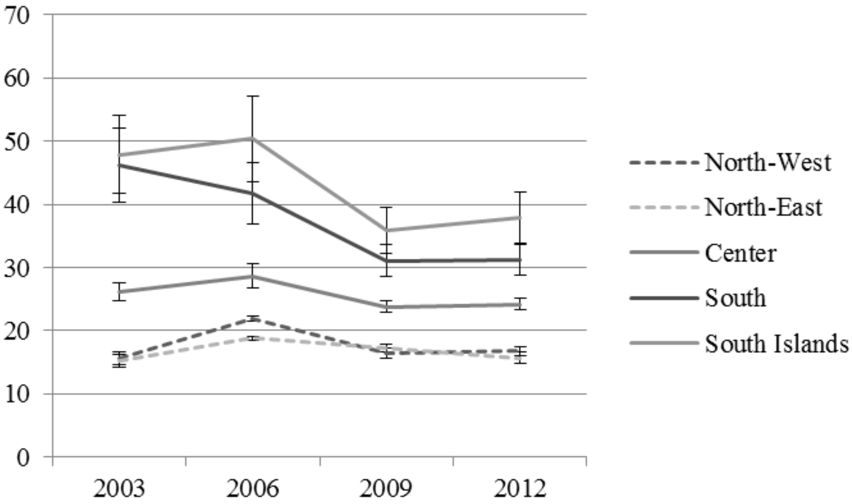
Figure 1. Student performance and equity by countries and Italian regions



Source: Based on graphs of PISA 2012 Results: Excellence through Equity (Volume II): Giving Every Student the Chance to Succeed - © OECD 2013

However, it is possible to have a longitudinal comparison on the main Italian areas: with respect to the 2003 edition, the macro-area of the South appears to have reduced the proportion at Level 0 and Level 1 by about 32% and the macro-area of the South-Islands by about 21% (Figure, 2)[9].

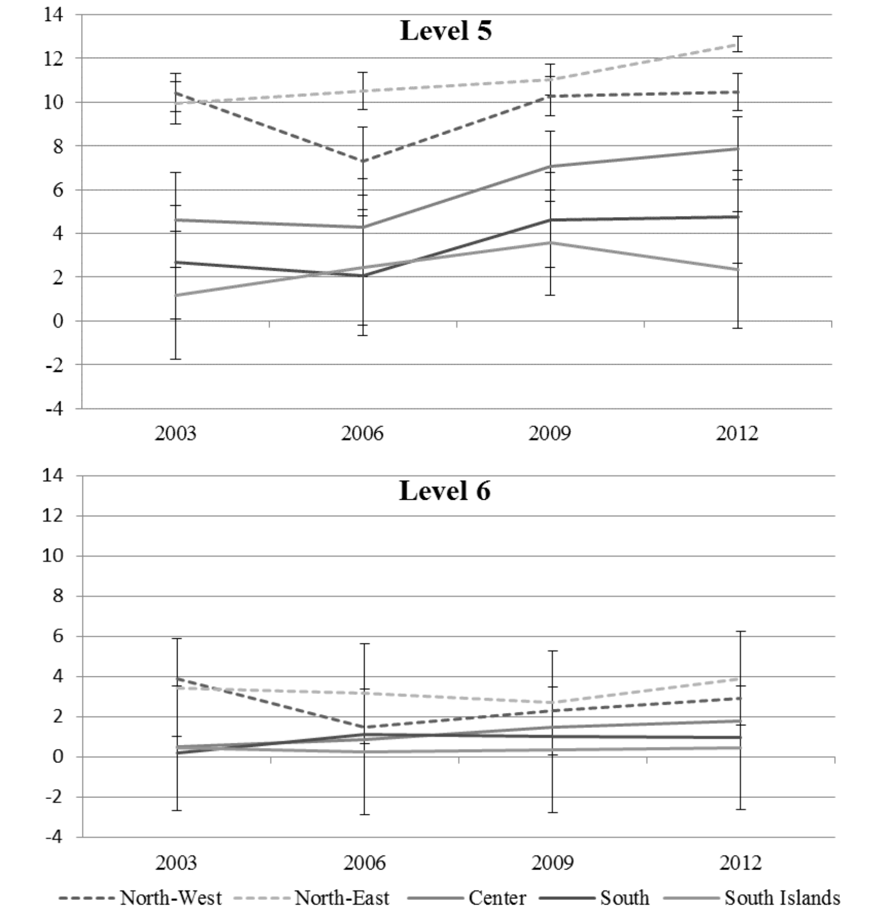
Figure 2. Percentage of Students at Level 0 and Level 1, mathematics. Longitudinal comparison by macro areas



Differently, the increase in the percentage of mathematical top-performers for macro area is not significant within each macro area (Figure, 3) throughout the different editions. The differences remain significant over time between the macro-areas of the North and the South, marking a clear difference in the proportion of top-performing students.

[9]- North-West (Piedmont, Lombardy, Liguria, Aosta Valley)
- North-East (Veneto, Friuli Venetia Giulia, Trentino Alto Adige, Emilia Romagna)
- Centre (Marche, Lazio, Tuscany, Umbria)
- South (Abruzzo, Molise, Campania, Apulia)
- South-Islands (Basilicata, Calabria, Sicily, Sardinia)

Figure 3. Percentage of Students at Level 5 and Level 6 mathematics. Longitudinal comparison by macro areas



In the 2012 edition, the OECD-PISA fixed excellence in mathematics at Level 5[10] (606.99 points) and Level 6[11] (669.30 points) reaching and

[10] "At Level 5, students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal

passing a performance score equal to 606.99 (the lower limit of Level 5). The passing performance score for excellence is fixed higher in the scale: 625.61 points (Level 5) or 698.32 (Level 6) in reading and 633.33 (Level 5) or 707.93 (Level 6) in science. According to this definitions, the nationwide excellence amounted to 9.9% in mathematics (7.7% at Level 5 and 2.2% at Level 6), 6.7% in reading (6.1% Level 5 and 0.6 at Level 6) and 6.1% in sciences (5.5% at Level 5 and 0.6% at Level 6). Three quarters of excellent students of maths, from what constitutes 9.9% of the total, are concentrated in the "lyceums"; almost another 2% are found in the technical institutes, while the share of excellence in regional and national vocational schools is virtually absent.

A look at the distribution of excellent Italian students by social origin show a very definite framework: top-performers students come mainly from an advantaged context[12] In particular, in lyceums close to the total (85.1%) of those who come from high family socio-economic cultural status reach Level 5 and Level 6. In lyceums, the 51.6% and the 32.6% of students coming from the third and second quartile of cultural and socio-economic status reach the excellence of Level 5 and Level 6; only the 18% who come from the more disadvantaged context reach this level. A very similar trend is found in technical institutes.

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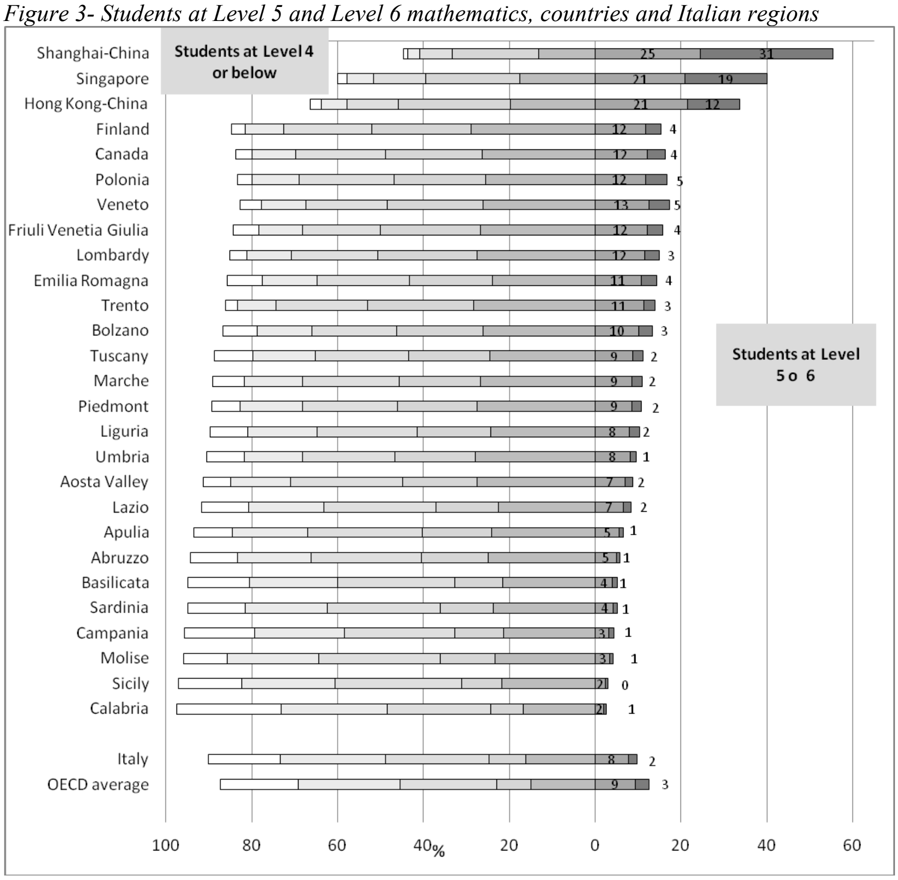
characterisations, and insight pertaining to these situations. They begin to reflect on their work and can formulate and communicate their interpretations and reasoning." (OECD 2014, p. 61).

[11] "At Level 6, students can conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. Students at this level can reflect on their actions, and can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situation" (OECD 2014, p. 61).

[12] In PISA, the index of cultural and socio-economic status is called ESCS index and it is avaible in the OECD dataset. The ESCS is a summary index centered with the OECD average of 0 and standard deviation equal to 1. This variable gathers the following indexes (OECD, 2012a): - the number of years of schooling (PARED) of the parent with higher education (ISCED); - the employment level of the parent with higher status (HISEI); - possession of the goods.

The national values on excellence (**Error! Not a valid bookmark self-reference.**) conceal strong regional differences: it goes from percentages of top-performers exceeding 16% (Trento, Friuli Venetia Giulia and Veneto) to values much less than 5% for other regions (Campania, Calabria and Sicily).

Figure 3- Students at Level 5 and Level 6 mathematics, countries and Italian regions



Source: Based on graphics PISA 2012 Results: What Students Know and Can Do (Volume I) - © OECD 2013

Resilient Top-Performers and Advantaged Top-Performer Students

Resilience is a construct that describes the process of creating wellbeing and positive development in lifelong learning, starting from normal conditions for human development or by considering how to overcome adversities and stressful situations. During the last decades, this construct has been contextualised in different settings and disciplines (e.g., psychological and emotional development, community action, environment, physics, health and medicine, learning and teaching), and only lately it has been introduced into the studies of performance evaluation (Garista, 2014).

Currently, several educational assessment systems have shown that in every country there is a significant proportion of "resilient students". Resilient students are those who come from a cultural and socio-economic disadvantage context but achieve relatively high performance in education (OECD, 2011; OECD, 2013a). In this section, it is observed that excellent students focus on their cultural and socio-economic background[13]. Two distinct groups of excellent students and one additional reference group , characterised by maximum deprivation of socio-economic status of origin and very low performance in order to compare data with support of Figure 5, had been created. *Resilient Top-Performers students*: those that come from absolutely the most modest (the first) quartile of cultural and socio-economic status performing at Level 5 and 6 in mathematics. *Advantaged Top-Performers students*: those that come from the fourth and highest quartile of cultural and socio-economic status performing at Level 5 and 6 in mathematics. *Disadvantaged*: those that come from absolutely the most modest (the first) quartile of cultural and socio-economic status performing at Level 0 and 1 in mathematics. As previously stated, the methodological definition of resilient students[14] is aligned to the one

[13] See note 13.

[14] For a comparison of Italian Regions of resilients, the students were defined as disadvantaged, - or non-disadvantaged relative to the cultural and socio-economic status of the specific region where they live. Disadvantaged students are those with an index of socio-economic and cultural status of PISA in the lower quartile of the distribution of that region. According to the criteria adopted by the OECD-PISA system, performance levels have been defined in the following way: performance thresholds were calculated by a regression of student performance net of the context of origin and, more precisely, on the basis of the

suggested by the OECD-PISA system (OECD, 2010) in order to achieve greater comparability about what a resilient student is.

The percentages of resilient students was calculated based on the index of ESCS[15]. The cultural and socio-economic status of the family of origin is currently one of the most important predictors of student performance in school subjects (Collins, 1988; Willms, 2003).

The definition of resilience accounts the quartiles of residual performance, net of cultural and socio-economic backgrounds. This is a grand definition of high performance: in the OECD-PISA scale, excellence is only at Level 5 and Level 6. In this way, the 84.3% of those previously defined as advantaged students are excellent students and only 14.2% are top-performer resilients. According by the grand definition of OECD-PISA, resilients from the most disadvantaged cultural and socio-economic status are mainly positioned in Level 3 (48%) and Level 4 (38%).

The analysis of disadvantaged low achievers, the resilient top-performers and the advantaged top-performers students show great different results between the Italian regions.

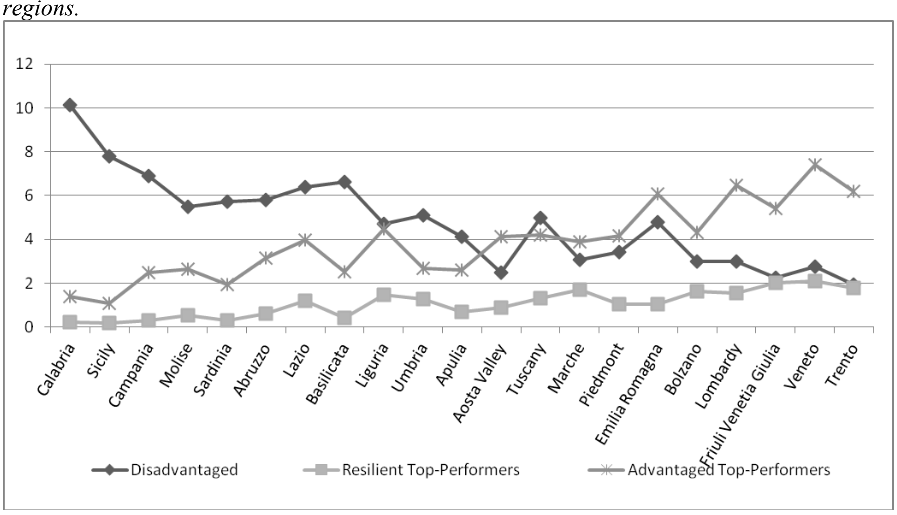
Figure 4 shows the percentages of disadvantaged students, resilient and advantaged high performing students. All areas are ordered on the basis of residual performance from the lowest to the highest, net of the cultural and socio-economic status of each region. The analysis of the cultural and socio-economic status for each region should prevent the effect of unbalance of this variable and it should ensure comparability between regions.

Index of socio-economic and cultural status (ESCS) (with a quadratic term to allow for the expression of non-linearity). Residuals were divided into quartiles of equal size. The data elaboration to obtain resilient students for Italy were conducted on the sample of students from all countries in order to obtain comparable performances among all students of all countries (with equal weight between countries)."Students were defined as strong resilient (or successful disadvantaged students) if they were performing in the highest quartile, net of socio-economic status and cultural background). Similarly, disadvantaged students are those who, net of a low socio-economic status, have performances that fall in the lowest quartile" (OECD, 2010, p.64 Note 6).

[15] See note 13.

Figure 4 shows important results: in each region, lower proportions of high performing students correspond to lower proportions of disadvantage low performing students. Trento, Veneto, Friuli Venetia Giulia and Lombardy are the areas with the higher percentage of higher performing students regardless of their cultural and socio-economic backgrounds. This region shows the smaller shares of disadvantaged students and, on the other hand, the larger shares of resilient students. It seems that students living in this area have more chances to obtain excellent performances. This is true even for those students coming from a more disadvantaged context.

Figure 4. Resilient Top-Performers, Advantaged Top-Performers and Disadvantaged, by regions.



A disadvantaged student in Lombardy, Friuli Venetia Giulia, Veneto and Trento has a better chance of reaching excellence compared to an advantaged student who lives in Calabria, Campania and Sicily. A disadvantaged student who lives in regions more capable of dealing with excellent students has about one-fifth of a chance to remain in the most disadvantaged quartile of performance compared to students living in the regions less able to guarantee excellence.

The logistic regression models

Up to this point, the characteristics of the top-performers have been investigated, according to some basic students and school variables. However, looking at the effect of one variable at a time, it is not possible to say to what extent the impact on excellent top-performers is "spurious" or to what extent it is influenced by other "intervening" variables. For example, it has been observed that some regions have a higher percentage of disadvantaged high performing students than others; it is not possible to say if this result depends on characteristics of the students or on specific characteristics of the schools belonging to those regions.

For this reason, in order to use the available data, the analysis will proceed through the estimation of the binary logistic regression model using the odds-ratios in order to understand the factors which characterise the top-performers in mathematics compared to those who are not top-performers (Table 1). The odds-ratios acquire value greater than one when the chance of the modality are considered superior to those of the reference category; they are between zero and one when they are lower and when the odds-ratio is equal to one they have the same value.

To better understand what characteristics influence the likelihood of being a top-performer according to the cultural and socio-economic status for each student, a second model has been created. It is based on a multinomial logistic regression that compares the resilient top-performers and advantaged top-performers with the category of not top-performers (Table 2). The coefficients for the variables considered will be shown for the main results.

Student characteristics

Gender

The excellent results for mathematics show significant differences between genders: Level 5 is reached by 9.9% of boys and nearly half, 4.6%, of girls. Level 6 (the highest level of excellence) is achieved by 3.1% of boys and just 1% of girls. The results are very similar for science albeit with a smaller differential: 6.5% of boys and 4.4% of girls achieve Level 5 and 0.7% of boys and 0.4% of girls achieve Level 6. The reading results are partially reversed and the girls results are slightly better both at Level 5 (7.6% of girls who reach this level and 4.6% of boys) and Level 6 (0.9% of girls and 0.4% of boys). The better results from the boys are confirmed across all the countries analysed in the OECD-PISA survey but the gap between boys and girls in excellence could be very different between countries[16].

All the Italian regions show similar results in gender gap: the gap is greater for Level 5 and higher in them than in the above-mentioned countries (INVALSI 2014b).

It is possible to interpret the gender gap in mathematical excellence from different perspectives. Some authors interpret the gender gap by analysing the assessment system from a methodological point of view. In particular, international standardised test show a disadvantage for girls for a number of reasons: first, boys perform better on standardized tests because since the primary socialization they are more use to competition (Steele, 1997). However, the second edition of PISA analysis shows that the sense of competition is quite similar for boys and for girls. Differences in mathematics seem to be more in how boys and girls 15 years old exert effort in the competition: girls are more aware than boys of the need to excel in studying in order to pass examinations (Fiore, 2008).

Secondly, standardised instruments neglect a "feminine" style more oriented towards open answers and are less limited by the closed-answer mode (Basinger, 1997; Gallagher & De Lisi, 1994; Sternberg & Williams, 1995). As said above, PISA use different type of questions and furthermore, also in Italy, students are even more used to this type of examination given that in the last 10 years this kind of examination are regularly done. Consequently, both males and females have fostered growing familiarity with this type of evaluation.

Finally, in standardised tests, stress “competition” is added to the stress generated by gender stereotypes in mathematics. The stress emerges when girls do not have the confidence to act in familiar environments, reassuring and free from bias. Differently in the comfortable climate due to the presence of teachers it could be reduced (Davies & Spencer, 2002).

[16] For example, Shanghai-China and Singapore as well as Finland and Canada, show very small gaps between genders. Hong Kong-China highlights major differences in Level 6.

The logistic regression binary model (Table 1) confirms that, on average, boys achieve higher results in excellence than girls (Gallagher & De Lisi 1994, Guiso, Monte, Sapienza & Zingales, 2008), net of all variables considered in the model that, for students' characteristics, are the following: immigration status (Ref. Native), cultural possession and cultural and socio-economic status, mathematics anxiety and self concepts, familiarity with mathematical concepts, mathematics extracurricular activities at school.

*Table 1. Logistic binary regression model of the chance to be a top-performing Student vs. Not top-performing student: Odds ratio, standard errors and p-value (***p<0.01, ** p<0.05, *p<0.1)*

		Top-performers vs. Not top-performers		
		Odds-ratios	*P-value*	*Standard Error*
Students 'characteristics	*Gender (Ref. Boy)*			
	Girl	**0.534**	***	(0.092)
	Immigration Status (Ref. Native)			
	First and Second Generation	**0.693**	**	(0.189)
	Cultural Possessions	**1.140**	**	(0.053)
	Cultural and socio-economic status (ESCS)	1.011		(0.957)
	Mathematics Anxiety	**0.686**	***	(0.062)
	Mathematics Self-Concept	**2.145**	***	(0.063)
	Familiarity with mathematical concepts	**1.947**	***	(0.052)
	Mathematics Extracurricular activities at school	**1.151**	***	(0.046)
Schools' characteristics	Student related factors affecting School Climate	**1.216**	***	(0.052)
	Proportion of girls at school	**0.401**	***	(0.284)
	Mean ESCS of School	**2.478**	***	(0.154)
	Proportion of maths teachers	**32.615**	***	(1.041)
	Student-Teacher ratio	**1.043**	***	(0.012)
	Type of school (Ref. Lyceums)			
	Technical Institute	**0.706**	**	(0.175)
	Vocational Schools	**0.088**	***	(0.562)
	Regional Vocational Schools	**0.188**	***	(0.527)
	Geographic area (Ref. North-West)			
	North-East	**1.626**	***	(0.119)
	Centre	**0.749**	**	(0.132)
	South	**0.363**	***	(0.154)
	South-Islands	**0.214**	***	(0.157)
	Constant	**0.050**	***	(0.319)
	N.	8,834		

About schools' characteristics: the student related factors affecting school climate, the proportion of girls at school, the mean ESCS of school, the proportion of math teachers, the student-teacher ratio, the type of school (Ref. Lyceums) and the geographical area (Ref. North West). Girls show a 53% probability of reaching excellence compared to boys. The gender analysis for groups of resilients (Table 2) shows that the gender gap is higher mainly between advantaged students and between those who come from disadvantaged context. It has to be noted that the lower chance girls have of being excellent students is confirmed, net of the anxiety variable. Anxiety is one of the factors with increased attention regarding the effect of gender on math performances (Steele, Spencer & Aronson, 2002).

Immigration status

The presence of more established immigration over time in Italy allowed this type of analysis be implemented in the PISA 2012 analysis. The percentage of first and second generation immigrants is about 7.3% in Italy. This percentage, even if less than the previous ten years, has grown compared to the PISA 2009 edition where the not-native student population was 5.5%. In particular, first generation students represent 5.5% (4.2% in 2009) and the second generation students represent 2% (1.3% in 2009) of the total student sample. Given that the percentage of second generation students (under the limit of 3% fixed by OECD in order to have statistically significant results) remains low, this last modality has been considered together with the first generation student's modality.

The logistic regression models show that being a not-native student is a penalty toward becoming an excellent student compared to native students (Table 1); not-native students show the 69% of chance of being excellent compared to native. Among the disadvantaged (Table 2), this condition does not appear to be significantly different, given the very low number of cases. Differently, the gap between advantaged native and advantaged not-native is significantly high (Table 2).

Cultural possessions

A number of theories argue that cultural goods are translated into cultural capital for the student, and that these, in turn, exert an influence on the performance levels of students (Willms, 2003).

*Table 2 – Logistic multinomial regression model of the chance to be resilient top-performers vs. not top-performers and advantaged top-performers vs. not top-performers: Coefficients, standard errors and p-value (***p<0.01,** p<0.05, *p<0.1)*

		Resilient Top Performers vs. Not Top Performers			*Advantaged Top-Performers vs. Not Top Performers*		
		Coefficient		*Standard Error*	*Coefficient*		*Standard Error*
Schools' characteristics	*Gender (Ref. Male)*						
	Girl	**-0.440**	*	(0.426)	**-0.563**	*	(0.141)
	Immigration Status (Ref. Native)						
	First and Second Generation	0.141		(0.371)	**-1.047**	*	(0.448)
	Cultural Possession	0.192		(0.133)	0.005		(0.098)
	Cultural and socio-economic status (ESCS)	**-3.056**	*	(0.134)	**1.751**	*	(0.121)
	Mathematics Anxiety	**-0.460**	*	(0.163)	**-0.337**	*	(0.098)
	Mathematics Self-Concept	**1.173**	*	(0.186)	**0.881**	*	(0.101)
	Familiarity with mathematical concepts	**1.063**	*	(0.135)	**0.677**	*	(0.079)
	Mathematics Extracurricular activities at school	-0.109		(0.137)	**0.273**	*	(0.073)
	Student related factors affecting School Climate	**0.371**	* *	(0.153)	**0.274**	* *	(0.502)
Schools' characteristics	Proportion of girls at school	-0.204		(0.728)	**-1.144**	*	(0.502)
	Mean ESCS of School	**1.539**	*	(0.437)	**0.749**	*	(0.235)
	Proportion of maths teachers	**8.225**	*	(3.206)	1.186		(1.583)
	Student-Teacher ratio	0.013		(0.039)	**0.700**	*	(0.21)
	Type of school (Ref. Lyceums)						
	Technical Institutes	0.118		(0.426)	**-0.568**	*	(0.312)
	Vocational Schools	-2.608		(0.436)	**-3.701**	*	(1.702)
	Regional Vocational Schools	**-2.927**	*	(1.157)	-	-	-
	Geographic area (Ref. North-West)						
	North-East	**1.068**	*	(0.348)	**0.446**	*	(0.189)
	Centre	0.560		(0.373)	**-0.362**	*	(0.205)
	South	**-2.064**	*	(0.533)	**-1.068**	*	(0.237)
	South-Islands	**-3.037**	*	(0.667)	**-1.557**	*	(0.264)
	Intercept	**-17.444**	*	(2.599)	**-30.805**	*	(2.399)
	N.	8,834			8,834		

In general, the index of cultural possessions seems to be a more consistent predictor of performance than the more general index ESCS. In general, those students with higher values of cultural possession have a 14% increased chance of being top-performers (Table 1). However, once one looks at the value within categories of resilience and advantaged this data is no longer statistically significant (Table 2).

The cultural and socio-economic status of the family of origin (ESCS)

The cultural and socio-economic status of the family of origin is currently one of the most used indicators to predict the performance of students in school disciplines (Collins 1988; Coleman et al., 1966). In the binary model, the odds-ratio relative to the ESCS does not seem to rely on the probability of being a top-performer (Table 1). The analysis for resilients and those that are advantaged show a strong ESCS on this particular category: very negative on resilients and very positive on advantaged (Table 2).

Math anxiety

As mentioned above, the attention of researchers has focused a lot on anxiety of students in mathematics. According to a series of studies, anxiety is generated by a negative message transmitted during the phases of the first socialisation (Newstead, 1998; Blatchford, 1996). This message causes the least capacity to carry out math tests in proportion to the difficulty of these tasks (Meece, Wigfield & Eccles, 1990). PISA asks students to report if they agree on the following statements: I often worry that it will be difficult for me in mathematics classes; I get very tense when I have to do mathematics homework; I worry that I will get poor grades in mathematics; I feel incompetent when I solve math problems; I get very nervous doing mathematics problems (OECD, 2013b).

In general, many students say they are particularly worried about mathematics. Anxious students report feeling more negative, are fearful and worried about the matter; this group of students show lower results compared to their colleagues who are less anxious. Part of this difference in results is due to the direct effect of anxiety on the activation of cognitive resources. This means that the more anxious student is unable to devote enough attention to the solution of a mathematical problem because they are too busy worrying about the task. Italian students have quite high levels of anxiety in all the main areas compared to the OECD average student.

The negative impact of this variable on performance is fairly uniform throughout the country, with values that lead to a decrease in the score that ranges from a minimum of 26 points in the South Islands up to 33 points in the North East, with an average decrease in national level of 31 points.

In addition, the difference in scores between students who are more anxious and those that are less anxious (interquartile range) was 70 points (OECD, 2013b).

The logistic regression models show the net effect of anxiety on the probability of being an excellent student: chances tended to decrease by about 32% if the student is anxious (Table 1). Advantaged (-0.337) and, in particular, disadvantaged top-performers (-0.460) are less anxious compared to all other students (Table 2).

Self-concept in mathematics (self-awareness of self)

PISA measures how much students believe in their own ability to deal with math tasks. The Student Questionnaire asks students how much they agree with the following statements: I am not so good at math; I achieve high marks in mathematics; I learn mathematics quickly; Mathematics has always been one of my favourite subjects; I also understand the more complex concepts in math class.

Italian students have a higher self-concept compared to OECD peers. In the South, most students believe in their own abilities more than do students in the North. The main areas where the impact of self-esteem is stronger are those in the North East and the South; there, an increase of this indicator implies an increase in the score in mathematics, 39 and 37 points respectively. Nationally, there is an increase of 32 points for each unit of the indicator (OECD, 2013b). The odds-ratios indicate a significant impact of this variable on the probability of being a top-performer where the chance of being top-performers show the coefficient 2.145 (Table 1) . This is true for top-performing students from an advantaged context (0.881) and, in particular, for students from a disadvantaged context (1.173) (Table 2).

Familiarity with the concepts of mathematics

Having some familiarity with mathematical concepts helps in the probability of being a top-performer (Table 1). This is especially true for resilient students (1.063), although this is a feature that increases the chances of being a top performers for students from an advantaged context (0.677).

Math extracurricular activities

PISA asks students to report how often (always, almost always, often, sometimes, rarely or never) students are involved in extracurricular school activities related to mathematics (OECD, 2013b). The mathematical activities considered are: talk about mathematical problems between friends; help friends with math; do math as an extra-curricular activity; participate in math competitions; do math for more than two hours outside of school; play chess; program the computer; and belong to a math club.

On average, Italian students participate more than their peers in OECD mathematical activities. The level of participation shows the strong variability between the areas: in Southern Italy, students participate more in mathematical activities than in the North. The impact of this activity, however, is more pronounced in Northern Italy with an increase in the score of 11 points in the Northwest. On a national level, having engaged in math seems not to affect math scores. The difference in scores between students who participate more and those who participate less in mathematical activities confirms the low impact of participation in these activities on math scores: the score difference amounts to only 3 points. About top-performers, the math extracurricular activities variable increases the chance of being top-performers (Table 1); this is in particular for advantaged students (0.273) while for disadvantaged student the value is not significant (Table 2).

Schools' characteristics

Climate study

The index for the climate of the study is built on the basis of the following items from the "school questionnaire" and is aimed to investigate the extent to which student learning is hindered by: unexcused absences, late arrivals, the presence of disrespectful behaviour towards teachers, vandalism, deviant behaviours (alcohol and illegal drugs), and intimidation and bullying from other students. The scale of the index is inverted with respect to the arrangement of items: higher values indicate positive behaviours (OECD, 2013b). The overall positive behaviour of students in school increases the chances of being top-performers similarly between advantaged and disadvantaged students (Table 2) where the values of the coefficient is 0.371 for disadvantaged students and 0.274 for advantaged students.

Percentage of girls in the school

An increase in the percentage of girls in schools corresponds to a decrease of the 60% in the probability of being a top-performer in mathematics (Table 1). This is confirmed in particular for advantaged students where the coefficient is equal to -1.144 while for disadvantaged student the value is not statistically significant (Table 2). Partially, this fact is explained by scholastic courses attended by boys and girls. Unfortunately, the PISA survey does not offer details about the specific types of schools but only if they are lyceums, technical institutes or vocational schools. Lyceums, in particular, show very different paths between them: in some cases characterised by very strong and structured mathematical courses (e.g., Scientific lyceums) and in other cases by weak mathematics courses (e.g., Human Science lyceums). The girls usually choose, to greater extent than boys, courses that require less mathematical skills (MIUR, 2014a).

Average ESCS

The average level of cultural and socio-economic status background of students in the school reveals that this indicator is significantly high among both resilient and advantaged. A higher level of cultural and socio-economic status of the school, therefore, appears to act positively on the probability of being a top-performer (Table 1). This indicator shows a great impact on advantaged students (0.749) and even a greater impact on disadvantaged students (1.539) (Table 2).

Proportion of math teachers

The proportion of mathematics teachers is obtained by dividing the number of math teachers by the total number of teachers in the school. This indicator seems to have a very strong influence on the performance of mathematics in general and its seems to be one of the most important indicator on the chance of being top-performers. The importance of the number of math teachers in the school is particularly important for students coming from a disadvantaged context (8.225) while the coefficient results not significant for advantaged students (Table 2).

Student/teacher ratio

The index is constructed by dividing the number of students by the total number of teachers. The part-time teachers were calculated as 0.5 while the full-time were weighted to 1.0. The odds-ratio suggests that where the rate of student/ratio is higher, the probability of being a top-performer should also increase. This probability is particularly significant for the advantaged where the coefficient is equal to 0.700; differently for disadvantaged students the value is not statistically significant (Table 2). It is reasonable to assume that the bigger schools could offer upgraded paths, including those relating to mathematics, more differentiated and more structured.

Type of school

As noted previously, one of the limitations of the PISA is to generically indicate the type of school not addressing the specific courses; the importance of mathematics can vary greatly between schools of the same type. However, the logistic regression model shows that, net of the variables included in the model and other things being equal, Lyceums are the type of school where the chance to be excellent increases (Table 1). Technical Institutes show a decrease of 30% in having top-performers students (Table 1). The low presence of excellent in national and regional vocational schools, in particular between advantaged students, make values not statistically significant in the model (Table 2).

Macro regional area

The results of the logistic models confirm the trend already seen in the descriptive analysis: living in a region of the North-West, and, especially, in the North-East greatly increases the chances of being a top-performer. The multinomial regression model confirms that living in the North and in particular in the North-East increases the chance to reach excellence if the student comes from a disadvantaged context compared to students that live in the Centre, in the South and, in particular, in the South and Island. About the Centre, the values of the regression models show a halfway situation between the North and the South. Definitively, students from the North-

East show the higher chance (1.626) of being top-performers compared to students from North-West (Reference Category) and to students from the other areas. Students from the Centre have the 75% of chance of being top-performers compared to students from North-West; students from South the 36% and students from South and Island the 21% (Table 1). It has to be noted that the differences in being top-performers are particularly relevant for disadvantaged students between the areas. Disadvantaged students from North-East have greater chance (1.068) of being top-performers compared to disadvantaged students from North-West (Reference Category) and other areas; the chance of disadvantaged students from Centre are not significantly different from those of the North-West while students from the South (-2.064) and, in particular, from South and Island (-3.037) show the worst situation in the opportunity of becoming top-performer students (Table 2).

Between the advantaged students the gap is less pronounced in the chances of becoming top-performers. In any case, even if less accentuated, the gap follows the same trend of disadvantaged students: the advantaged students from North-East show the higher chance of being top-performers (0.446) compared to the students of North-West (Reference Category) and to students from all the other areas; advantaged students from Centre (-0.362), South (-1.068) and South and Islands (-1.557) show the lower chance in becoming top-performers.

Conclusion

The national framework relies on a percentage of 9.9% of top-performers and this makes Italy's position exactly halfway between the 65 OECD and non-OECD countries that in the 2012 participate to the survey. Especially in the case of mathematics, the ability to access the universal language should offer to the students the possibility to measure themselves beyond national borders. Regarding excellence, as well as the performance mean scores, the differences between regions are very important. There are different opportunities for boys and girls in terms of reaching excellence if the students live in the North or in the South of the country.

The focus on excellence by geographic area is very relevant: in the face of a school system that is as formally uniform across the country, different opportunities arise for different geographical areas. In particular the analysis shows the increased disadvantage for those student that come from a disadvantaged familiar context and that live in the South area: they have less chance of being excellent students compared to their colleagues that live in the North.

According to the PISA results, currently the South does not guarantee the compensation of these inequalities, as it seems to happen to a greater extent in the North of Italy. Usually, students from the South Island show higher self-awareness in their own abilities compared to students living in the North but their results are lower (at least as revealed by the PISA score). Differently from the PISA score, in the final examination the results show a higher level of excellence in the South than in the North area (MIUR 2014b). As said in the introduction, currently, educational policies evaluate excellence in schools on the basis of final examination at the end of secondary education in order to award students who are top-performing. In this way the topic of identifying with rigorous criteria excellent students assume a central relevance.

There is also the issue of gender inequality. It is well known that increased female participation in the labour market ensures a substantial increase in the gross domestic product (GDP) of the country (OECD, 2012). Similarly, increasing the excellence focus on girls may increase the human capital of the country and, in a cascade, a number of issues related to the labour market and GDP. Primarily boys currently reach excellence in mathematics. The theories that show more credit on gender differences in mathematics refer to the persistence of gender stereotypes in mathematics. This stereotype seems to be activated more strongly during adolescence. The stereotype reflects in factors such as higher math anxiety, lower self-awareness and lower self-confidence. This motivation is one point on which educational policies should focus. Second, it is observed that the gender difference is mainly in more fragile mathematical school courses. Girls, their families and not infrequently, their teachers choose, to greater extent, this courses for girls more than for boys. Here it is possible to operate along two paths: on the one hand, the orientation of girls towards more structured courses in mathematics and the other hand, the strengthening of the mathematical content. Educational policies needs to increase the proportion of mathematics teachers in order to obtain more robust paths in the basic skills of mathematics.

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