# An Analysis of the Performance of Italian Schools in Bebras and in the National Student Assessment INVALSI

Carlo Bellettini carlo.bellettini@unimi.it Violetta Lonati violetta.lonati@unimi.it Anna Morpurgo anna.morpurgo@unimi.it Mattia Monga mattia.monga@unimi.it

Università degli Studi di Milano Dept. of Computer Science Via Celoria 18, 20133 — Milan, Italy

## Abstract

This paper analyzes the results of the Bebras Challenge on Informatics and Computational Thinking held in Italy in the last three years and it compares them to the overall performance of Italian schools in the national IN-VALSI assessment of the standardized levels reached by students in Italian, Mathematics, and English. The main research question is if the mean regional performance at INVALSI tests can predict the performance of schools of the same region in the Bebras challenge. The answer is positive at the grossest level: macro regional areas with INVALSI results below the national average tend to perform worse also in the Bebras challenge. At regional level, a high correlation between Bebras and INVALSI was found among the regions whose results differ significantly.

## 1 Introduction

The Bebras International Challenge on Informatics and Computational Thinking (http://bebras.org) is

a yearly contest organized since 2004 [Dag10, HCD11]. In 2018 almost three million participants from 54 countries took part to one of the locally organized events. The contest, open to pupils of all school levels (from primary up to upper secondary), is based on tasks rooted on core informatics concepts and computational thinking, yet independent of specific previous knowledge such as for instance that acquired during curricular activities. In fact Bebras tasks avoid the use of jargon and are especially aimed at a non-vocational audience, focusing on that part of informatics that should become familiar to everyone, not just computing professionals. The tasks are supposed to provide an entertaining learning experience, and they are designed by the Bebras community to be moderately challenging and solvable in a relatively short time. The setting of the contest is slightly different in each country, but in general participants have to solve a set of about 10-15 tasks in an average time of three minutes for each. In Italy, the Bebras is open to teams of 3 or 4 pupils, divided in five age groups: I (grades 4–5, ages  $\approx$ 9–10), II (grades 6–7, ages  $\approx$ 11– 12), III (grade 8, age  $\approx 13$ ), IV (grades 9–10, ages  $\approx 14$ – 15), V (grades 11–13, ages  $\approx 16-18$ ). In the last three editions we had 36,018 teams, from schools located in all the 20 administrative regions Italy is subdivided into (see Table 3). Besides being used during the contests, Bebras tasks are an opportunity for educational activities [DS16, LMM<sup>+</sup>17, CAC<sup>+</sup>18]. Moreover, Bebras was used to measure improvements of students' attitude to computational thinking [SBS17]. The study examined 21 schools (children aged 9–11) which participated in "Code Clubs". The primary outcome measure was a set of Bebras tasks, which 317

Copyright © 2019 for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

In: I. Fronza, C. Pahl (eds.): Proceedings of the 2nd Systems of Assessments for Computational Thinking Learning Workshop (TACKLE 2019), co-located with 14th European Conference on Technology Enhanced Learning (EC-TEL 2019), 17-09-2019, published at http://ceur-ws.org.

pupils completed at baseline and endpoint. We wonder, instead, if the performances in Bebras follow the general level of competencies of the schools participating to the contest. In order to answer this question, one should have a measure of the curricular achievements of the schools (or even the classes) involved, but unfortunately these data are not publicly available. In fact, one of the Bebras' goals is to spread the acquaintance with informatics and computational thinking among every school population, even (or maybe especially) those not naturally attracted by computing. To this end, we avoid any participation fee and we try to keep the competition at a level such that nobody should feel ashamed to participate: Bebras should be perceived as an opportunity to have fun and learn something, not to show off the performances of the schools. For example in Italy, although every teacher receives ranking data about their teams, only the very top of the ranking is published (the best eight teams in each age group, with at most one team per school). Thus, we do not want to ask teachers about the marks of their pupils in the curricular activities or other proxies of their academic success. Instead, we tried to understand if the results in the Italian Bebras contest were somewhat correlated with the general school performances in the same territory. For this, we resort to INVALSI data, the national student assessment program, similar to OECD's Programme for International Student Assessment (PISA) or IEA's Trends in International Mathematics and Science Study (TIMSS) and Progress in International Reading Literacy Study (PIRLS).

Since school year 2005/6, all the pupils of the Italian school system at the end of grade 2, 5, 8, and 10 are evaluated by an INVALSI standardized test, aimed at measuring their proficiency in Italian, Mathematics, English listening and English reading. According to the 2018 INVALSI report, the performances of the twenty Italian regions differ in a significant way, at least from grade 8 and up. Thus, we set up a study aimed at understanding if these differences are reflected in the results we see in the Bebras contest. The number of Bebras teams is much smaller than the number of students involved in the INVALSI assessment (even by considering that their public data are based on a sample, see below), moreover Bebras participation depends on teachers' interest, while INVALSI is mandatory. Nevertheless, we wanted to understand if Bebras data reflect the general geographic pattern of the wider population of Italian schools.

The paper is organized as follows: in Section 2 we formalize our research questions, in Section 3 we describe our approach, in Section 4 we report our analyses, and finally in Section 5 we draw some conclusions.

# 2 The research questions

The 2018 INVALSI assessment [INV18] tested 29,520 grade 5 classes (562,635 pupils), 29,032 grade 8 classes (574,506 pupils), and 26,361 grade 10 classes (543,296 pupils). In order to guarantee data quality, a sample of students was observed directly during the test: the data reported publicly is based on this direct analysis of 29,371 grade 5 students, 31,300 grade 8 students, and 48,664 grade 10 students. In grade 5 the test is paper based and manually marked, while in the other grades the test is computer based and automatically marked. Results are separately assessed for four areas of competence: 'Italian', 'Mathematics', 'English listening', and 'English reading' (in 2018, grade 10 was not tested for English). Public data cover all the twenty Italian regions (Trentino-Alto Adige is actually divided into two autonomous provinces, since in the region live communities with different mother-tongues, no aggregated regional data are provided). Results are provided at two levels of aggregations:

- 1. five geographic macro-areas: North-West, North-East, Center, South, South-Islands;
- 2. 21 administrative regions (19 regions and 2 autonomous provinces).

Table 1 shows the mean performance by area; the average is set at 200 (with a standard deviation of 40).

According to the INVALSI report [INV18], the differences among the areas at grade 5 are small<sup>1</sup>. Instead, the differences are considered increasingly significant in the higher grades. Overall they are claimed to match similar results in PISA assessment (surveyed internationally every three years) with the North part of the country performing better than the national average, and the South part worse than the national average; the Center instead reflects the national average. The report also mentions that the Northern part of the country has better than average results in recent TIMMS assessments.

The regional data are more detailed, since they report also the standard deviation of the distributions, not only the means. The data are shown in Table 2.

In this study, our goal is to understand if this variability is reflected in the results of the Italian Bebras. We have homogeneous data for the last three editions (2016, 2017, 2018). The total number of partecipating teams is reported in Table 3.

Bebras data involve a smaller number of schools with respect to INVALSI (which aims at being "universal" in the Italian school system: the participation

 $<sup>^1{\</sup>rm Grade}~2$  has even smaller differences; it was not considered here, since the Italian Bebras involves pupils from grade 4 up to grade 13

area	grade	Italian	Mathematics	English listening	English reading
Center	5	204	204	207	205
North-East	5	202	203	203	204
North-West	5	203	202	203	203
South	5	195	197	192	194
South-Islands	5	192	191	192	191
Center	8	205	204	204	205
North-East	8	206	211	214	210
North-West	8	207	207	214	209
South	8	190	188	184	188
South-Islands	8	189	186	178	184
Center	10	200	201		
North-East	10	210	213		
North-West	10	210	212		
South	10	192	189		
South-Islands	10	185	182		

Table 1: INVALSI results by macro area. The standardized national mean is 200. English was not tested at grade 10.

is mandated by law. In the past it was also used to mark students at grade 8, but the 2018 edition was not used for this purpose). Nevertheless we would like to use them to try to answer the following research questions.

## RQ1

Is there any correlation between the average ability of Bebras teams in a specific region and the regional performance in INVALSI tests?

#### RQ2

Is there any correlation between the average ability of Bebras teams in a geographic macro area and the area performance in INVALSI tests?

## RQ3

Is the overall performance trend at INVALSI tests, with Northern schools performing better than the national average and Southern schools performing worse, reflected also in Bebras results?

# 3 Methodology

We estimated the ability of the Bebras teams by fitting an Item Response Theory (IRT) [HS85] model with two parameters. IRT is routinely used to evaluate massive educational assessment studies like OECD's PISA, and it has already been applied to Bebras and other informatics competitions [KVC06, HM14, BLM<sup>+</sup>15]. Moreover, a similar IRT model is behind the INVALSI data as described in [Des18].

IRT models each solver with an *ability* ( $\theta$ ) parameter and links it to the probability of a correct solution via a logistic function. Such a function is a characteristic of each task (*item*) and it defines its *response* to the solver ability. Response functions are described

by a number of parameters: we used a model with two parameters, the *difficulty* ( $\delta$ ) of a task and its *discrimination* ( $\alpha$ ). Difficulty locates the response function: if the ability of the solver is greater than the difficulty of a task, the probability of solving it is greater than 0.5. Discrimination defines the slope of the response curve: a high discrimination means that a small increase in the ability of the solver has a great impact on the probability of solving the task; a discrimination = 0 defines a task in which the ability of the solver does not matter at all. Figure 1 shows some examples of logistic response functions. It is worth noting that all that counts in the model are the relative values of the parameters (there is no absolute measure of ability): thus to fit it to data it is necessary to *identify* ability with conventional values. In order to be comparable with INVALSI data, we deviated from the common practice [GH06] of assuming that, overall, ability has mean = 0 with respect to an arbitrary reference point and standard deviation = 1. Instead, we assumed a mean ability = 200 and a standard deviation = 40.

In order to estimate the difficulty and discrimination of each task, we implemented the probabilistic model with Stan [Sta16]. Stan is a software tool which, given a statistical model, uses Hamiltonian Monte Carlo sampling (a very efficient form of Markov chain Monte Carlo sampling) to approximate the *posterior* probability of the parameters of interest.

$$P(\theta_i|Y) \quad i \in \text{teams}$$
 (1)

where  $\theta_i$  is the ability of team *i*. The statistical model sampled is a hierarchical one, with the following *prior* distributions:

ABRUZZO       South       5       203       40       202       40       197       39       198       39         BASILICATA       South-Islands       5       204       49       211       40       202       44         CALABRIA       South-Islands       5       192       41       192       41       189       42       188       44         EMILA-ROMAGNA       North-East       5       203       39       201       40       202       37       204       39         LAZIO       Canter       5       201       39       203       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       204       39       203       41       208       43       189       43       189       43       189       43       189       43       189       43       189       43       189       44       189       44       189	region	area	grade	Italian	$\sigma$	Mathematics	$\sigma$	Eng. listening	$\sigma$	Eng. reading	σ
BASILICATA       South-Fishmade       5       204       39       211       40       201       40       202       41       180       30       201       41         CAMPRIA       South       5       180       41       193       41       180       42       188       41         CAMPANIA       South-Fishmake       5       204       39       208       42       205       38       206       39       201       30       201       30       201       30       201       30       201       30       201       30       201       30       201       30       201       30       201       30       201       40       203       40       201       40       203       40       203       40       203       40       203       40       203       40       203       40       203       40       201       38       200       38       200       38       201       43       43       43       43       43       43       43       43       43       43       43       43       44       44       44       44       44       44       44       44       44       44 <td>ABRUZZO</td> <td>South</td> <td>5</td> <td>203</td> <td>40</td> <td>202</td> <td>40</td> <td>197</td> <td>39</td> <td>198</td> <td>39</td>	ABRUZZO	South	5	203	40	202	40	197	39	198	39
CALABRIA South-Islands 5 192 41 192 41 189 39 191 40 CAMPANIA South 5 189 41 193 41 189 42 188 41 FMILLA-ROMAGNA North-East 5 204 39 208 40 202 37 204 39 IAZIO Center 5 202 40 201 38 207 41 204 40 ILCURIA North-West 5 201 39 201 39 200 30 201 39 ILAZIO Center 5 206 39 208 40 205 38 207 41 204 40 ILCURIA North-West 5 201 39 201 39 200 40 205 39 MARCHE Center 5 206 39 208 40 214 47 204 39 MARCHE Center 5 206 39 208 40 214 47 204 39 MARCHE Center 5 206 39 208 40 214 45 204 41 INFONA South-Islands 5 201 41 202 46 214 45 204 41 INFONA South-Islands 5 201 41 202 46 214 45 208 41 INFONA South-Islands 5 207 39 208 40 210 53 40 205 SARDEGNA South-Islands 5 194 40 188 37 187 37 194 39 SCILLA South-Islands 5 194 40 188 39 193 43 199 43 TORCANA Center 5 206 38 206 39 203 41 21 199 43 TORCANA Center 5 206 38 207 40 210 38 206 39 UMBRIA Contro-ADTO ADIGE Center 5 206 38 206 39 203 41 211 39 MARCHE Conter 5 206 38 206 39 203 41 21 199 43 TORCANA Center 5 203 37 198 38 UMBRIA Contro-ADTO ADIGE Center 5 202 37 203 38 202 233 41 211 39 ABRUZZO South 8 201 38 200 38 198 38 203 39 UMBRIA Conth-Wast 5 203 37 198 38 UNERDIVINO-ADTO ADIGE Center 5 206 38 206 39 203 31 214 33 201 38 ABRUZZO South 8 201 38 200 38 198 38 203 39 UMBRIA South-Islands 8 185 40 181 37 198 33 UNARRIA South-Islands 8 185 40 181 37 198 33 UNARRIA South-Islands 8 185 40 181 37 198 33 214 43 ERUILA-PONAGNA North-East 8 207 40 211 41 215 35 120 38 ABRUZZO South 8 201 38 200 38 203 38 204 38 ABRUZZO South 8 205 38 201 38 203 38 204 38 ABRUZZO South 8 205 38 201 40 210 33 208 38 ABRUZA SOUTH 8 205 39 201 38 203 38 214 35 AADALABRIA NORTH-West 8 205 38 201 40 210 33 208 38 ABRUZA SOUTH NORTH-West 8 207 37 210 38 207 37 205 38 ABRUZAN NORTH-West 8 207 37 211 41 32 213 37 ABRUZCO South 8 203 39 206 40 210 33 208 34 ABRUZA SOUTH-Islands 8 185 39 1192 38 186 38 192 39 ABRUZAN SOUTH-Islands 8 198 37 192 35 190 318 34 14 35 CALABRIA SOUTH-Islands 8 198 37 192 35 190 318 34 13 37 ABRUZAN ASOUTH-Islands 8 198 37 192 48 34 213 37 ABRUZAN ASOUTH-Islands 10 190 38 206 37 CALAB	BASILICATA	South-Islands	5	204	39	211	40	201	40	202	41
CAMPANIA South 5 189 41 193 41 180 42 188 41 EMILIA-ROMAGNA North-East 5 203 39 201 40 202 37 204 39 FRUELV-VENEZIA GIULIA North-East 5 204 39 208 42 205 48 205 39 FRUELV-VENEZIA GIULIA North-East 5 201 39 201 38 207 41 204 40 LIGURA North-West 5 201 39 202 40 205 40 205 39 MARIEL COMBARDIA North-West 5 201 39 202 40 205 40 205 40 PIEMIONTE North-West 5 201 39 202 40 205 40 205 40 PIEMIONTE North-West 5 201 39 202 40 205 40 205 40 PIEMIONTE North-West 5 202 30 203 41 198 43 800 39 SIGULA South-Islands 5 190 40 188 37 187 37 194 39 SIGULA South-Islands 5 190 40 188 37 187 37 194 39 SIGULA South-Islands 5 190 40 188 39 103 43 189 43 TOSCANA Center 5 207 39 207 39 208 39 207 40 210 38 VALE D'AOCTA North-West 5 203 37 198 38 VALE D'AOCTA North-Mest 5 204 37 203 38 198 38 199 38 ASSULZZO South 8 201 38 200 38 198 38 198 38 ASSULZZO South 8 185 40 181 36 170 41 177 41 CAMPANIA South-Islands 8 195 39 183 38 199 38 ASSULZZO South 8 185 40 181 36 170 41 177 41 CAMPANIA South-Islands 8 185 40 181 36 170 39 183 42 EMILLA-ROMAGNA North-East 8 206 39 201 38 203 38 201 38 ASULCAT South-Islands 8 185 40 181 36 170 39 183 42 ASSULZZO South 8 205 39 210 38 203 38 201 38 ASULCAT South-Islands 8 185 40 181 36 170 39 183 42 ASULCAT South-Islands 8 185 40 181 36 170 39 133 42 35 ASULCAT South-Islands 8 185 40 181 36 170 39 133 424 35 LAZIO Center 8 208 39 201 40 218 37 212 37 AMRCILE Couter 8 208 39 201 40 218 37 212 37 AMRCILE Couter 8 208 39 201 40 218 37 212 37 AMRCILE South-Islands 8 185 30 188 204 37 205 36 AGUEST South-Islands 8 187 30 185 36 177 39 133 209 35 ALZIO Center 8 206 39 200 40 210 33 209 35 ALZIO Center 8 207 37 210 38 204 37 205 36 AGUEST South-Islands 8 187 39 192 33 209 35 ALZIO Center 8 207 37 210 38 204 37 205 38 AGUEST South-Islands 8 198 37 192 35 190 39 AGUEST South-Islands 8 198 37 192 35 190 39 AGUEST South-Islands 8 198 37 205 37 AGUEST South-Islands 8 198 37 205 37 AGUEST South-Island	CALABRIA	South-Islands	5	192	41	192	41	189	39	191	40
EMILIA-ROMAGNA         North-East         5         203         39         201         40         202         37         204         38           LAZIO         Center         5         202         40         201         38         207         31         204         40         205         38         205         39         201         39         201         39         200         39         201         39         200         39         201         39         201         39         200         40         205         39           LOMBARDIA         North-West         5         201         31         201         31         201         31         201         31         201         31         201         31         201         38         201         33         201         31         33         201         33         201         33         201         39         201         33         201         33         201         33         201         33         201         33         201         33         201         33         201         33         201         33         201         33         201         33         201         33<	CAMPANIA	South	5	189	41	193	41	189	42	188	41
FRIUL-VENEZIA GUULA         North-East         5         204         39         208         42         205         38         205         38           LAZIO         Center         5         201         39         201         39         200         39         201         39         201         39         200         39         201         39         201         39         200         39         201         38         202         35         203         37         203         38         201         38         202         35         203         37         203	EMILIA-ROMAGNA	North-East	5	203	39	201	40	202	37	204	39
LAZIO       Center       5       202       40       201       38       207       41       204       49         LOMBARDIA       North-West       5       201       39       202       40       205       39         MARCHE       Center       5       206       39       204       46       214       45       208       41         MOLISE       South       5       210       41       202       46       214       45       208       41         PICAIDNTE       North-West       5       202       39       203       41       198       38       200       39         SARDEGNA       South-Islands       5       194       40       188       37       187       37       194       39         SICLIA       Center       5       205       38       207       39       203       31       188       34       199       38         VALE D'AOSTA       North-East       5       203       37       198       38       202       35       203       37       40         CAMPANIA       South-Islands       8       185       39       218       38 <t< td=""><td>FRIULI-VENEZIA GIULIA</td><td>North-East</td><td>5</td><td>204</td><td>39</td><td>208</td><td>42</td><td>205</td><td>38</td><td>205</td><td>39</td></t<>	FRIULI-VENEZIA GIULIA	North-East	5	204	39	208	42	205	38	205	39
LICURIA         North-West         5         201         39         201         38         201         38         201         38         202         35         203         37         183         43         185         40         38         200         38         198         38         198         38         198         38         198<	LAZIO	Center	5	202	40	201	38	207	41	204	40
LOMBARDIA       North-West       5       204       39       202       40       205       40       205       40       205       40       205       40       205       40       30         MAIRCIIE       South       5       210       41       220       46       214       45       200       439         PUCLIA       South-Islands       5       194       40       188       37       157       37       194       39         SICILIA       South-Islands       5       194       40       189       39       133       43       189       43         SICILIA       South-Islands       5       194       40       188       37       187       39       202       40       210       38       202       30       207       40       210       38       202       35       203       37       40       211       38       202       35       203       37       40       213       36       187       40       214       31       36       17       43       44       45       421       435       421       35       41       435       421       35       421	LIGURIA	North-West	5	201	39	201	39	200	39	201	39
MARCHIE       Center       5       206       39       208       39       204       37       204       39         PICLIA       South       5       202       39       203       41       198       38       201       39         SARDECNA       South-Islands       5       194       40       188       37       137       37       194       39         SICLLA       South-Islands       5       194       40       188       37       137       37       194       39         SICLLA       South-Islands       5       194       40       189       39       203       31       121       39         UMBRIA       Center       5       206       38       207       40       210       38       206       38         VALLE D'AOSTA       North-East       5       202       37       203       38       198       38       197       40         ARBUZO       South       8       195       39       183       38       197       34       35       101       38       204       38       187       40       13       39       213       33       213	LOMBARDIA	North-West	5	204	39	202	40	205	40	205	39
MOLISE         South         5         210         41         220         46         214         45         200         41           PIEMONTE         North-West         5         202         39         203         41         198         38         200         39           PUCLIA         South-Islands         5         194         40         188         37         187         37         194         39           SICILIA         South-Islands         5         194         40         189         38         207         39         208         39         237         40           TRENTINO-ALTO ADICE*         North-East         5         205         38         207         40         210         38         206         38           VALE <d'aosta< td="">         North-West         5         203         37         198         38         190         38         190         38         190         38         190         38         197         40         177         41           CALAPRIA         South-Islands         8         155         39         189         37         121         31         121         13         35         113</d'aosta<>	MARCHE	Center	5	206	39	208	39	204	37	204	39
PLEAD(N1E)       North-West       5       202       41       203       41       195       38       201       39         SARDBCNA       South-Islands       5       194       40       188       37       187       37       194       30         SARDBCNA       South-Islands       5       190       40       189       39       193       43       189       43         TCSCANA       Center       5       207       39       207       40       213       38       206       38         UMBRIA       North-East       5       206       38       207       40       213       38       200       38       200       38       200       38       209       37       40       213       38       109       37         ABRUZZO       South -Islands       8       195       39       189       37       183       35       187       40       137       40       215       35       210       38       204       38       197       39       183       42       183       38       197       39       183       42       184       38       197       39       143       <	MOLISE	South	5	210	41	220	46	214	45	208	41
POLLAR       South       South-Islands       5       202       11       202       40       193       35       200       39         SIRDECNA       South-Islands       5       194       40       188       37       187       37       194       39         SICLIA       South-Islands       5       190       40       189       39       207       30       208       39       207       40       103       38       206       38       200       38       223       41       211       39         VALLE D'AOSTA       North-East       5       203       37       198       38       199       38       20       38       20       38       20       38       199       38       35       190       31       37       103       35       117       40       214       181       36       170       41       177       41       41       430       417       41       41       430       181       36       170       41       177       41       41       416       411       117       41       421       433       32       210       33       210       32       210	PIEMONTE	North-West	5	202	39	203	41	198	38	201	39
SILUDATA         South-Balands         5         194         40         185         31         151         31         194         33           SICLILA         Center         5         207         39         207         39         208         39         207         40           TRENTINO-ALTO ADICE*         North-East         5         206         38         207         40         210         38         206         38           VALLE D'AOSTA         North-Vest         5         203         37         203         38         198         35         199         38           VENETO         North-Vest         5         202         37         203         38         198         35         187         40           CALARIA         South-Islands         8         185         40         181         36         170         41         177         41           CAMPANIA         South-Islands         8         185         42         183         38         199         33         214         35           LAZIO         Center         8         206         39         201         38         203         38         204         38<	PUGLIA	South Islands	Э 5	202	41	202	40 27	195	38 27	200	39
SICULIA         SOUTH-BRINDS         0         190         40         193         39         430         189         43           TOSCANA         Center         5         207         30         208         39         223         41         211         39           VALLE D'AOSTA         North-East         5         206         38         207         40         210         38         206         38           VALLE D'AOSTA         North-East         5         203         37         198         38         202         35         203         37           ABRUZZO         South         8         201         38         200         38         198         35         197         40           CALABRIA         South-Isands         8         185         40         181         36         177         41         177         41           CALABRIA         South-Isands         8         185         40         181         36         182         33         214         35         201         38         203         32         214         35         204         38         204         38         204         38         204 <td< td=""><td>SARDEGNA</td><td>South-Islands</td><td>0 E</td><td>194</td><td>40</td><td>100</td><td>37 20</td><td>107</td><td>31 49</td><td>194</td><td>39</td></td<>	SARDEGNA	South-Islands	0 E	194	40	100	37 20	107	31 49	194	39
LOBINAL       Center       5       207       39       200       39       201       39       201       39       201       39       201       39       201       39       201       39       201       39       201       39       201       39       201       38       206       38       201       38       202       37       203       38       202       35       203       37       198       38       202       35       203       37       198       38       202       35       203       37       198       38       202       35       203       37       103       35       189       38       199       38       35       187       40       36       114       17       40       201       38       107       41       17       40       201       38       104       38       179       39       183       42       183       38       179       39       183       42       181       36       179       39       183       42       181       36       207       37       10       35       201       38       204       38       204       38       204	TOSCANA	South-Islands	5	190	40 20	169	39 20	195	45 20	169	40
Intervention       Intervent       5       206       38       203       39       242       41       211       38       206       38         VALLE D'AOSTA       North-West       5       203       37       198       38       202       35       203       37       203       38       202       35       203       37         INUZZO       South-Islands       8       195       39       189       37       183       35       187       40         CALABRIA       South-Islands       8       195       39       189       37       183       35       187       40         CALABRIA       South-Islands       8       185       40       181       36       170       41       177       41         CALABRIA       North-East       8       207       40       211       41       215       35       210       38       243       37       210       35       207       37       37       33       214       35       210       38       204       32       210       35       207       37       37       33       208       36       216       39       210       32 <td>TRENTINO ALTO ADICEª</td> <td>North Fast</td> <td>5</td> <td>207</td> <td>38</td> <td>207</td> <td>30</td> <td>200</td> <td>39 41</td> <td>207</td> <td>30</td>	TRENTINO ALTO ADICEª	North Fast	5	207	38	207	30	200	39 41	207	30
CALLE D'AOSTA       North-West       5       203       37       198       38       200       35       203       37       198       38         VENETO       North-East       5       202       37       203       38       202       35       203       37         ABRUZZO       South-Islands       8       105       39       189       37       183       35       187       40         CALABRIA       South-Islands       8       195       39       180       37       183       35       187       40         CAMFANIA       South-Islands       8       185       42       183       38       179       39       118       42         EMILL-VENEZIA GIULIA       North-East       8       206       38       201       38       203       38       204       38         LAZIO       Center       8       205       38       204       37       210       35       207       37         LAZIO       Center       8       202       39       204       201       33       208       36       197       39         LAZIO       Center       8       202 <td< td=""><td>IMBRIA</td><td>Center</td><td>5</td><td>200</td><td>38</td><td>208</td><td>40</td><td>225</td><td>38</td><td>211 206</td><td>38</td></td<>	IMBRIA	Center	5	200	38	208	40	225	38	211 206	38
VENETO         Numberson         South	VALLE D'AOSTA	North-West	5	200	37	108	38	210	00	200	00
ABRUZZO         South         8         201         38         203         204         203         204         203         201         38         198         34         41         177         41         177         41           CALABRIA         North-East         8         207         40         211         41         215         35         210         38         204         38         210         38         203         38         204         38         204         38         204         38         204         38         204         38         204         38         204         38         204         38         204         37         210         35         207         37         104         36         197         39         183         41         204         37         203         39	VENETO	North-East	5	203	37	203	38	202	35	203	37
ABID 220         South         8         201         38         200         38         198         35         199         36         199         37         183         35         187         40           CALABRIA         South-Islands         8         185         40         181         36         170         41         177         41           CAMPANIA         South-East         8         207         40         211         41         215         35         210         38           EMULA-ROMAGNA         North-East         8         205         38         201         38         203         38         204         35           LGURIA         North-West         8         205         38         204         37         210         35         207         37           LOMBARDIA         North-West         8         202         39         203         39         206         35         203         38           DIGLIA         South-Islands         8         195         39         192         35         190         36         192         39           SICLIA         South-Islands         8         197         39		Gauth		202	20	200	200	102	20	100	
DABLIZATA       South-Islands       8       195       39       189       37       183       35       36       187       40         CALABRIA       South       8       185       42       183       36       170       41       177       41         CALABRIA       North-East       8       207       40       211       41       215       35       210       38         FRULLA-ROMAGNA       North-East       8       206       35       211       31       210       38       203       38       204       38         LGURIA       North-West       8       205       39       201       38       203       38       204       38         LGURIA       North-West       8       205       39       204       37       210       35       203       38       204       38       204       38       204       36       197       39       183       41       176       41       177       41       30       38       204       37       212       38       186       38       190       36       122       38       186       38       190       36       197       3	ABRUZZO	South	8	201	38	200	38	198	38	199	38
$ \begin{array}{cccc} CALPARIA & South & S & 183 & 40 & 161 & 30 & 10 & 41 & 177 & 41 \\ CALPARIA & South & S & 185 & 42 & 183 & 38 & 179 & 39 & 183 & 42 \\ EMILIA-ROMAGNA & North-East & S & 207 & 40 & 211 & 41 & 215 & 35 & 210 & 38 \\ FIULI-VENEZIA GUULIA & North-East & 208 & 35 & 213 & 39 & 219 & 33 & 214 & 35 \\ LAZIO & Center & S & 205 & 39 & 201 & 38 & 203 & 38 & 204 & 38 \\ LIGURIA & North-West & S & 205 & 38 & 204 & 37 & 210 & 35 & 207 & 37 \\ LOMBARDIA & North-West & S & 209 & 39 & 210 & 40 & 218 & 37 & 212 & 37 \\ MARCHE & Center & S & 208 & 38 & 209 & 40 & 210 & 33 & 208 & 36 \\ MOLISE & South & S & 202 & 38 & 202 & 40 & 194 & 36 & 197 & 39 \\ PIEMONTE & North-West & S & 202 & 39 & 203 & 39 & 206 & 35 & 203 & 38 \\ PUGLIA & South & S & 198 & 37 & 192 & 38 & 186 & 38 & 192 & 39 \\ SARDEGNA & South-Islands & S & 198 & 37 & 192 & 35 & 190 & 36 & 192 & 39 \\ SICILIA & South-Islands & S & 198 & 37 & 192 & 35 & 190 & 36 & 192 & 39 \\ SICILIA & South-Islands & 8 & 198 & 37 & 192 & 38 & 204 & 37 & 205 & 36 \\ TRENTINO-ALTO ADIGEa North-East & 207 & 37 & 210 & 38 & 207 & 37 & 203 & 38 \\ VALLE D'AOSTA & Center & 8 & 207 & 37 & 210 & 38 & 207 & 37 & 205 & 38 \\ VALLE D'AOSTA & North-West & 8 & 209 & 36 & 209 & 37 & 214 & 33 & 208 & 34 \\ VENETO & North-East & 8 & 205 & 37 & 211 & 40 & 211 & 33 & 208 & 34 \\ VENETO & North-East & 10 & 207 & 38 & 196 & 37 \\ CALABRIA & South & 10 & 196 & 38 & 196 & 37 \\ CALABRIA & South & 10 & 189 & 43 & 186 & 38 \\ LAZIO & Center & 10 & 207 & 38 & 210 & 40 \\ FIULI-VENEZIA GIULIA & North-East & 10 & 207 & 38 & 210 & 40 \\ FIULI-VENEZIA GIULIA & North-East & 10 & 207 & 38 & 216 & 37 \\ LOWBARIA & South & 10 & 198 & 38 & 196 & 37 \\ LOWBARIA & North-West & 10 & 206 & 37 & 207 & 38 \\ PUGLIA & North-West & 10 & 206 & 37 & 207 & 38 \\ PUGLIA & South & 10 & 193 & 38 & 191 & 37 \\ SARDEGNA & South & 10 & 193 & 38 & 191 & 37 \\ SARDEGNA & South & 10 & 193 & 38 & 191 & 37 \\ SARDEGNA & South-Islands & 10 & 183 & 44 & 178 & 34 \\ SOUTH & South & 10 & 193 & 38 & 207 & 42 \\ VALLE D'AOSTA & North-East & 10 & 215 & 33 & 219 & 37 $	CALADDIA	South-Islands	8	195	39	189	31	183	30	187	40
CAMILAROMAGNA       North-East       8       207       40       211       41       215       35       210       38         FRULLAROMAGNA       North-East       8       208       35       213       39       219       33       214       35         LAZIO       Center       8       205       38       201       38       203       38       204       38         LGURIA       North-West       8       209       39       210       40       218       37       212       37         LOMBARDIA       North-West       8       209       39       204       40       210       33       208       36         MACCHE       Center       8       202       39       203       39       206       35       203       38       192       39         SARDEGNA       South-Islands       8       198       37       192       35       100       36       192       39       133       204       37       205       36         SICILIA       South-Islands       8       187       39       185       36       177       39       183       41       75       35	CAMPANIA	South-Islands	0	185	40	181	30	170	41 20	183	41
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	EMILLA ROMACNA	North Fast	0	207	42	210	30 41	215	35	210	44
IABOLIV LEAR ORDERA       North-East       5       245       53       243       53       244       53       244       53       244       35       217       35       217       35       217       37       210       35       207       37         LIGURIA       North-West       8       209       39       210       40       218       37       212       37         MARCHE       Center       8       209       39       210       40       218       37       212       37         MARCHE       Center       8       202       38       202       40       194       36       197       39         PIEMONTE       North-West       8       202       39       203       39       206       35       203       38         SARDEGNA       South       8       198       37       192       35       190       36       192       39         SICLIA       South-Islands       8       187       39       185       36       177       39       183       41         TOSCANA       Center       8       207       37       210       38       204       37 <td>ENILIA-ILONIAGNA</td> <td>North East</td> <td>8</td> <td>207</td> <td>40 25</td> <td>211 212</td> <td>30</td> <td>210</td> <td>22</td> <td>210</td> <td>35</td>	ENILIA-ILONIAGNA	North East	8	207	40 25	211 212	30	210	22	210	35
LIGURIA       North-West       8       205       35       204       37       210       35       204       37       210       35       207       37         LOMBARDIA       North-West       8       209       39       210       40       218       37       212       37         LOMBARDIA       North-West       8       202       38       202       40       194       36       197       39         MARCHE       Center       8       202       38       202       40       194       36       197       39         PIEMONTE       North-West       8       202       39       203       39       206       35       203       38         SARDEGNA       South-Islands       8       187       39       185       36       177       39       183       41         TOSCANA       Center       8       203       39       207       38       204       37       205       36         VALLE D'AOSTA       North-East       8       207       37       210       38       207       37       216       38       204       37       205       38         <	LAZIO	Center	8	208	30	213	38	219	38	214 204	38
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	LIGURIA	North-West	8	205	38	201 204	37	200	35	204	37
MARCHE       Center       8       208       38       209       40       210       33       208       36         MOLISE       South       8       202       38       202       40       194       36       197       39         PIEMONTE       North-West       8       202       38       202       40       194       36       197       39         SARDEGNA       South-Islands       8       195       39       192       38       186       38       192       39         SICILIA       South-Islands       8       187       39       185       36       177       39       183       41         TOSCANA       Center       8       203       39       207       38       204       37       205       36         TRENTINO-ALTO ADIGE"       North-East       8       207       37       210       38       207       37       205       38         VALLE D'AOSTA       North-East       8       205       37       211       40       211       33       208       34         VENETO       North-East       10       199       39       200       40 <td< td=""><td>LOMBARDIA</td><td>North-West</td><td>8</td><td>209</td><td>39</td><td>210</td><td>40</td><td>218</td><td>37</td><td>212</td><td>37</td></td<>	LOMBARDIA	North-West	8	209	39	210	40	218	37	212	37
MOLISE       South       8       202       38       202       40       194       36       197       39         PIEMONTE       North-West       8       202       39       203       39       206       35       203       38         PUGLIA       South-Islands       8       195       39       192       35       190       36       192       39         SARDEGNA       South-Islands       8       187       39       192       35       190       36       192       39         SICILIA       South-Islands       8       187       39       207       38       204       37       205       36         TOSCANA       Center       8       207       37       214       39       218       34       213       37         UMBRIA       Center       8       207       37       210       38       207       37       205       38         VALLE D'AOSTA       North-West       8       209       36       209       37       214       33       208       34         ABSUZZO       South-Islands       10       196       38       196       37       216 <td>MARCHE</td> <td>Center</td> <td>8</td> <td>208</td> <td>38</td> <td>209</td> <td>40</td> <td>210</td> <td>33</td> <td>208</td> <td>36</td>	MARCHE	Center	8	208	38	209	40	210	33	208	36
PIEMONTE       North-West       8       202       39       203       39       206       35       203       38         PUGLIA       South       8       195       39       192       38       186       38       192       39         SARDEGNA       South-Islands       8       198       37       192       35       190       36       192       39         SICILIA       South-Islands       8       187       39       185       36       177       39       183       41         TOSCANA       Center       8       207       37       214       39       218       34       213       37         UMBRIA       Center       8       207       37       210       38       207       37       205       38         VALLE D'AOSTA       North-West       8       209       36       209       37       214       33       208       34         VENETO       North-East       10       199       39       200       40       40       41       33       209       35         CALABRIA       South-Islands       10       189       43       186       38	MOLISE	South	8	202	38	202	40	194	36	197	39
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	PIEMONTE	North-West	8	202	39	203	39	206	35	203	38
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	PUGLIA	South	8	195	39	192	38	186	38	192	39
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	SARDEGNA	South-Islands	8	198	37	192	35	190	36	192	39
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	SICILIA	South-Islands	8	187	39	185	36	177	39	183	41
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	TOSCANA	Center	8	203	39	207	38	204	37	205	36
UMBRIACenter820737210382073720538VALLE D'AOSTANorth-West820936209372143320834VENETONorth-East820537211402113320935ABRUZZOSouth10199392004040BASILICATASouth-Islands101814217635CALABRIASouth-Islands101894318638EMILIA-ROMAGNANorth-East102073821438LAZIOCenter102093521438LAZIOCenter102053720639LOMBARDIANorth-West102053720639LOMBARDIANorth-West102044220843MARCHECenter102063720738PIEMONTENorth-West102063720738PUGLIASouth-Islands101834417834SARDEGNASouth-Islands101874118444TOSCANACenter102003820339TRENTINO-ALTO ADIGE <sup>a</sup> North-East102153321937VALLE D'AOSTANorth-East102053920742VALLE D'AOSTANorth-East1	TRENTINO-ALTO ADIGE <sup><math>a</math></sup>	North-East	8	207	37	214	39	218	34	213	37
VALLE D'AOSTANorth-West820936209372143320834VENETONorth-East820537211402113320935ABRUZZOSouth101993920040BASILICATASouth-Islands101963819637CALABRIASouth-Islands101814217635CAMPANIASouth101894318638EMILIA-ROMAGNANorth-East102073821040FRIULI-VENEZIA GIULIANorth-East102093521438LAZIOCenter10205372063943LOMBARDIANorth-West102053720639LOMBARDIANorth-West102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth-Islands101833434TOSCANACenter102063820339TRENTINO-ALTO ADIGE <sup>a</sup> North-East102153321937UMBRIACenter102053920742VALLE D'AOSTANorth-East102153321937UMBRIACenter1020633204354	UMBRIA	Center	8	207	37	210	38	207	37	205	38
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	VALLE D'AOSTA	North-West	8	209	36	209	37	214	33	208	34
ABRUZZOSouth101993920040BASILICATASouth-Islands101963819637CALABRIASouth-Islands101814217635CAMPANIASouth101894318638EMILIA-ROMAGNANorth-East102073821040FRIULI-VENEZIA GIULIANorth-East102093521438LAZIOCenter101983819637LIGURIANorth-West102053720639LOMBARDIANorth-West102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101874118434TOSCANACenter102003820339TRENTINO-ALTO ADIGE"North-East102153321937UMBRIACenter102053920742VALLE D'AOSTANorth-West102063720738VENETONorth-East102033820339TRENTINO-ALTO ADIGE"North-East102153321937UMBRIACenter10205392074	VENETO	North-East	8	205	37	211	40	211	33	209	35
BASILICATA       South-Islands       10       196       38       196       37         CALABRIA       South-Islands       10       181       42       176       35         CAMPANIA       South       10       189       43       186       38         EMILIA-ROMAGNA       North-East       10       207       38       210       40         FRIULI-VENEZIA GIULIA       North-East       10       209       35       214       38         LAZIO       Center       10       198       38       196       37         LIGURIA       North-West       10       205       37       206       39         LOMBARDIA       North-West       10       213       35       215       39         MARCHE       Center       10       204       42       208       43         MOLISE       South       10       194       42       195       40         PIEMONTE       North-West       10       206       37       207       38         SICILIA       South-Islands       10       183       44       178       34         SICILIA       South-Islands       10       187	ABRUZZO	South	10	199	39	200	40				
CALABRIASouth-Islands101814217635CAMPANIASouth101894318638EMILIA-ROMAGNANorth-East102073821040FRIULI-VENEZIA GIULIANorth-East102093521438LAZIOCenter101983819637LIGURIANorth-West102053720639LOMBARDIANorth-West102133521539MARCHECenter102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101874118434TOSCANACenter102053920742UMBRIACenter102053920742VALLE D'AOSTANorth-West102083320435	BASILICATA	South-Islands	10	196	38	196	37				
CAMPANIASouth101894318638EMILIA-ROMAGNANorth-East102073821040FRIULI-VENEZIA GIULIANorth-East102093521438LAZIOCenter101983819637LIGURIANorth-West102053720639LOMBARDIANorth-West102133521539MARCHECenter102063720738PUEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102053920742VALLE D'AOSTANorth-West102053321937VENETONorth-East102083320435	CALABRIA	South-Islands	10	181	42	176	35				
EMILIA-ROMAGNANorth-East102073821040FRIULI-VENEZIA GIULIANorth-East102093521438LAZIOCenter101983819637LIGURIANorth-West102053720639LOMBARDIANorth-West102133521539MARCHECenter102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102053920742VALLE D'AOSTANorth-West102053920742VENETONorth-West102083320435	CAMPANIA	South	10	189	43	186	38				
FRIULI-VENEZIA GIULIANorth-East102093521438LAZIOCenter101983819637LIGURIANorth-West102053720639LOMBARDIANorth-West102133521539MARCHECenter102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102053920742VALLE D'AOSTANorth-West102083320435VENETONorth-East102083320435	EMILIA-ROMAGNA	North-East	10	207	38	210	40				
LAZIOCenter101983819637LIGURIANorth-West102053720639LOMBARDIANorth-West102133521539MARCHECenter102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102053920742VALLE D'AOSTANorth-West102083320435VENETONorth-East102133621637	FRIULI-VENEZIA GIULIA	North-East	10	209	35	214	38				
LIGURIANorth-West102053720639LOMBARDIANorth-West102133521539MARCHECenter102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102053321937UMBRIACenter102053920742VALLE D'AOSTANorth-West102083320435VENETONorth-East102133621637	LAZIO	Center	10	198	38	196	37				
LOMBARDIANorth-West102133521539MARCHECenter102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102003820339TRENTINO-ALTO ADIGE <sup>a</sup> North-East102153321937UMBRIACenter102083320435VENETONorth-East102133621637	LIGURIA	North-West	10	205	37	206	39				
MARCHECenter102044220843MOLISESouth101944219540PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102003820339TRENTINO-ALTO ADIGE <sup>a</sup> North-East102153321937UMBRIACenter102083320435VENETONorth-East102133621637	LOMBARDIA	North-West	10	213	35	215	39				
MOLISE       South       10       194       42       195       40         PIEMONTE       North-West       10       206       37       207       38         PUGLIA       South       10       193       38       191       37         SARDEGNA       South-Islands       10       183       44       178       34         SICILIA       South-Islands       10       187       41       184       34         TOSCANA       Center       10       200       38       203       39         TRENTINO-ALTO ADIGE <sup>a</sup> North-East       10       205       39       207       42         VALLE D'AOSTA       North-West       10       208       33       204       35         VENETO       North-East       10       213       36       216       37	MARCHE	Center	10	204	42	208	43				
PIEMONTENorth-West102063720738PUGLIASouth101933819137SARDEGNASouth-Islands101834417834SICILIASouth-Islands101874118434TOSCANACenter102003820339TRENTINO-ALTO ADIGE <sup>a</sup> North-East102153321937UMBRIACenter102083320435VENETONorth-East102133621637	MOLISE	South	10	194	42	195	40				
F UGLIA     South     10     193     38     191     37       SARDEGNA     South-Islands     10     183     44     178     34       SICILIA     South-Islands     10     187     41     184     34       TOSCANA     Center     10     200     38     203     39       TRENTINO-ALTO ADIGE <sup>a</sup> North-East     10     215     33     219     37       UMBRIA     Center     10     205     39     207     42       VALLE D'AOSTA     North-West     10     208     33     204     35       VENETO     North-East     10     213     36     216     37		North-West	10	200	37	207	38 27				
SAUDEGRA         South-Islands         10         163         44         176         54           SICILIA         South-Islands         10         187         41         184         34           TOSCANA         Center         10         200         38         203         39           TRENTINO-ALTO ADIGE <sup>a</sup> North-East         10         215         33         219         37           UMBRIA         Center         10         205         39         207         42           VALLE D'AOSTA         North-West         10         208         33         204         35           VENETO         North-East         10         213         36         216         37	FUGLIA SARDECNA	South Johnson	10	193 199	38 44	191	२/ २/				
TOSCANA     Center     10     20     38     203     39       TRENTINO-ALTO ADIGE <sup>a</sup> North-East     10     215     33     219     37       UMBRIA     Center     10     205     39     207     42       VALLE D'AOSTA     North-West     10     208     33     204     35       VENETO     North-East     10     213     36     216     37	SICILIA	South-Islands	10	100 187	44 /1	184	04 24				
TODOLATATO2003620339TRENTINO-ALTO ADIGE <sup>a</sup> North-East102153321937UMBRIACenter102053920742VALLE D'AOSTANorth-West102083320435VENETONorth-East102133621637	TOSCANA	Centor	10	200	41 39	104	34 30				
Intervisional Controlational Controlation     Item Provision     Item Provision     Item Provision     Item Provision       UMBRIA     Center     10     205     39     207     42       VALLE D'AOSTA     North-West     10     208     33     204     35       VENETO     North-East     10     213     36     216     37	TRENTINO ALTO ADICE <sup>a</sup>	North Fast	10	200	33 90	200 910	39 37				
VALLE D'AOSTA         North-West         10         208         33         204         35           VENETO         North-East         10         213         36         216         37	IIMBRIA	Center	10	215	30 30	219 207	19 19				
VENETO         North-East         10         213         36         216         37	VALLE D'AOSTA	North-West	10	205	33	201	35				
	VENETO	North-East	10	213	36	216	37				

 $^{a}$ The data refer only to the autonomous province of Trento.

Table 2: INVALSI results by region. The standardized national mean is 200. English was not tested in grade 10 and data about English in Valle d'Aosta at grade 5 are not available. Trentino-Alto Adige is divided into two provinces and no aggregated datum is available.

area	region	Grade 5	Grade 8	Grade 10
Center	LAZIO	13,466	2,617	4,787
Center	MARCHE	1,572	1,746	1,976
Center	TOSCANA	3,034	2,470	1,342
Center	UMBRIA	1,771	234	713
	Total	19,843	7,067	8,818
North-East	EMILIA-ROMAGNA	4,079	4,117	4,891
North-East	FRIULI-VENEZIA GIULIA	708	1,357	4,588
North-East	TRENTINO-ALTO ADIGE	60	1,774	713
North-East	VENETO	$11,\!197$	7,403	$9,\!623$
	Total	$16,\!044$	$14,\!651$	$19,\!815$
North-West	LIGURIA	2,118	1,485	6,373
North-West	LOMBARDIA	30,416	$14,\!125$	$13,\!878$
North-West	PIEMONTE	6,235	4,814	3,167
North-West	VALLE D'AOSTA	672	954	0
	Total	39,441	21,378	$23,\!418$
South	ABRUZZO	2919	660	823
South	CAMPANIA	18,764	6,420	$3,\!673$
South	MOLISE	576	971	375
South	PUGLIA	14,822	7,426	1,423
	Total	37,081	$15,\!477$	6,294
South-Islands	BASILICATA	101	727	310
South-Islands	CALABRIA	1,759	917	1,105
South-Islands	SARDEGNA	684	1,730	514
South-Islands	SICILIA	3,169	3,005	1,581
	Total	5,713	6,379	$3,\!510$

Table 3: Total numbers of Bebras teams by region (data cover editions 2016, 2017, 2018)



Figure 1: Logistic response functions

$$\begin{split} \overline{\delta} &\sim Cauchy(200,5), \sigma_{\alpha}, \sigma_{\delta} \sim Cauchy(0,5), \\ \theta &\sim Normal(200,40), \\ \delta &\sim Normal(\overline{\delta}, \sigma_{\delta}), \qquad \alpha \sim LogNormal(0,\sigma_{\alpha}) \\ y &\sim BernoulliLogit(\alpha \cdot (\theta - (\delta + \overline{\delta}))/40). \end{split}$$

In this model we assumed a Cauchy weakly informative prior distribution on hyper-parameters  $\overline{\delta}$  — the mean difficulty used as a reference point in the logistic —,  $\sigma_{\delta}$ , and  $\sigma_{\alpha}$  — the standard deviation respectively of difficulty and discrimination —. The ability is then supposed to be normally distributed with mean = 200 and standard deviation = 40, the difficulty normally distributed with mean = 0 and standard deviation =  $\sigma_{\delta}$ , and the logarithm of discrimination is normally distributed with mean = 200 and standard deviation =  $\sigma_{\alpha}$ . The correctness y of each item is finally sampled according to a Bernoulli process where the probability of success is computed with the logistic model described above. These are quite standard choices for Bayesian IRT (see [GH06, Sta16]). We sampled the Stan Monte Carlo model for 2,000 iterations, throwing away the first 1000 results (50% warm-up iterations). The results have all the typical properties of converging models, in particular the  $\hat{R}$  statistics is close to 1 for every parameter of interest (a necessary, but unfortunately not sufficient, condition for convergence). Results are indeed sensible, with descriptive statistics consistent with score data, therefore we are rather confident that our model is plausible and useful to infer latent parameters.

# 4 Data analysis

In order to answer the research questions posed in Section 2, we start by identifying which variations among Bebras data are indeed significant. Ideally, we would like to filter out the differences due to statistical fluctuations. In fact, even the INVALSI 2018 report warns the readers that the differences in grade 5 results are too small to be considered a true assessment of the local competencies [INV18]. Unfortunately the report does not give enough details to replicate the significance test they used. We used a t-test between each pair of areas and regions, and we considered as significant those in which the *t*-test has a *p*-value  $< 1 \times 10^{-4}$ (*i.e.*, the "null" hypothesis that the two generating distributions have the same mean is less probable than  $\frac{1}{10000}$ ). Table 4 collects the significance of the results grouped by macro-area: only a few differences are significant at grade 5, but the overall significance increases with grades 8 and 10.

A similar pattern is also found when the results are grouped by regions, as reported in Table 5.

#### 4.1 Analysis at the regional level

When one considers Bebras and INVALSI results grouped by region, the correlation among the rankings of the means is rather low. Tables 6,7, and 8 give the Kendall rank correlation coefficients respectively for grade 5, grade 8, and grade 10. The correlation increases with grades, but several inversions among the rankings remain.

In order to also appreciate the impact of the standard deviation of the results, we give the pictures of the distributions too (see Figures 2, 3, and 4, respectively grade 5, 8, and 10), approximated with a Gaussian with the same mean and standard deviation.

We also investigated if, whenever the difference in Bebras results between two regions is considered significant (see Table 5), the difference is in the same "direction" of the difference in INVALSI (please note, however, that we do not have detailed enough data to test if the difference in INVALSI results is also significant). For example, VENETO and CAMPANIA have a significant difference in Bebras results: VENETO performed better than CAMPANIA, and the same is true with respect to INVALSI tests.

For grade 5, we found 10 significant differences between regions, the differences have the same direction for 4 pairs. In the other 6 pairs, the directions differ: Bebras difference has the same direction of 'English reading' in 5 cases, of 'English listening' in 4 cases, of 'Italian' in 4 cases, of 'Mathematics' in 4 cases; thus, 17 cases out 24 are in the same direction.

For grade 8, we found 31 significant differences between regions and the differences have the same direction for all.

For grade 10, we found 78 significant differences between regions, the differences have the same direction for 63 pairs. In the other 15 pairs, the directions differ: Bebras difference has the same direction of 'Italian' in 1 case, in all other 29 cases the direction of Bebras difference is opposite of the difference in Italian and Mathematics, which instead are consistent between them.

All in all, we believe we have preliminary evidence that the answer to RQ1 is somewhat positive: at least when the difference is significant, the difference in Bebras mostly matches INVALSI differences.

#### 4.2 Analysis at the level of macro-areas

With the exception of grade 5 (see Table 9, but at this grade, as noted above, the differences are mostly not significant), the correlation among the rankings of the means grouped by macro-areas is rather high. Tables 10 and 11 give the Kendall rank correlation coefficients respectively for grade 8 and grade 10.

Thus, also for RQ2 we believe we have evidence to answer positively, at least for the grades 8 and 10, where the differences between the results of the macroareas are considered significant.

#### 4.3 Analysis at the grossest level

The INVALSI 2018 report claims that the overall INVALSI results generally match PISA results: the Northern part of Italy performs better than the national average, while the Southern part performs worse. This pattern, with the best mean results in the two Northern macro-areas and the worst mean results in the two Southern macro-areas, is found also in Bebras. According to Bebras data, the Center macroarea performs slightly below the national average.

Thus, RQ3 seems also positively supported by our data.

#### 4.4 Threats to validity

The 2018 INVALSI report does not give the details about the significance tests used to mark the differences at grade 5 as not significant, while at grades 8 and 10 they were considered so. Also, no pairwise (at both regional and macro-area levels) significance was reported. Since the Bebras sample is much smaller, we used a rather tight criterion: a *t*-test with a *p*value threshold  $< 1 \times 10^{-4}$ . The underlying statistical model is the same in INVALSI and Bebras (2parameter IRT), but we do not know the fitting ap-

Area	Center	North-East	North-West	South	South-Islands
Center	_	10	5	8	8 10
North-East	10		10	$5\ 8\ 10$	8 10
North-West	5	10	—	$5\ 8\ 10$	5 8 10
South	8	5 8 10	5 8 10		10
South-Islands	8 10	8 10	5 8 10	10	_

Table 4: Significance of the difference in Bebras results by macro-area, measured by a *t*-test. Cells show the grades in which the *p*-value is less than  $1 \times 10^{-3}$ , the threshold we used to reject the hypothesis that the two distributions have the same mean.

Region	LAIO	MARC	HE TOSCE	UMBR UMBR	LA LICUR	LONBAR	DIA PIEMON	TE VALL	E DI AOSTA	PRINT FRUIT	NA IVENEILA TRENT	NO ALTO	ADIGE	CAMPAT	PAOLE	SE PUGILA	BASIL	CATA CALAP	SRIA SICILIA	SADDECT
LAZIO MARCHE TOSCANA UMBRIA	10	10	10 10 —	_	10 10	$5\begin{array}{c} 5 \\ 10 \\ 10 \end{array}$	5 10 10		10 10 10	10	10	10 10		8 10	10 10 10	10	10	10 10	8 10 8 10 8 10 10	10
LIGURIA LOMBARDIA PIEMONTE VALLE D'AOSTA	$\begin{array}{c}10\\5\ 10\\5\ 10\end{array}$	10 10	10			8 10 	10 10	8	10 10	10 10	10	10 10	5 5 10	$     \begin{array}{r}       10 \\       5 8 \\       5 8 10 \\       8     \end{array}   $	10 10	$5810 \\ 510 \\ 8$	10	8 10 10 8	$     \begin{array}{r}       10 \\       8 10 \\       8 10 \\       8     \end{array} $	10
EMILIA-ROMAGNA FRIULI-VENEZIA GIULIA TRENTINO-ALTO ADIGE VENETO	10 10	10 10 10	10	10	10 10 10	10	10 10 10		10 10 10	10	10	10	10	8 10 8 8 5 8 10	10 10 10	8 10 8 10 5 8 10	10		8 10 8 10 8 10 8 10 8 10	10
ABRUZZO CAMPANIA MOLISE PUGLIA	10		8 10 10 10	10	10	$5 \\ 5 \\ 10 \\ 5 \\ 8 \\ 10$	$5 10 \\ 5 8 10 \\ 10 \\ 5 10$	8 8	10 8 10 10 8 10	8 10 8 10	8	$5810 \\ 10 \\ 5810$	-	10	10 	_		10	10 10	
BASILICATA CALABRIA SICILIA SARDEGNA	10 8 10	8 10	10 10 8 10 10	10	10	8 10 8 10	$     \begin{array}{c}       10 \\       10 \\       8 10 \\       10 \\       10     \end{array} $	8 8	$  \begin{array}{c c} 10 \\ 8 \ 10 \\ 8 \ 10 \\ 10 \end{array}  $	8 10 8 10	8 8 10	$     \begin{array}{r}       10 \\       8 \ 10 \\       8 \ 10     \end{array} $	10	10 10			-	_	_	

Table 5: Significance of the difference in Bebras results by region, measured by a *t*-test. Cells show the grades in which the *p*-value is less than  $1 \times 10^{-4}$ , the threshold we used to reject the hypothesis that the two distributions have the same mean.

	Italian	Mathematics	Eng. listening	Eng. reading	Bebras
Italian	1.00	0.65	0.67	0.77	0.10
Mathematics	0.65	1.00	0.57	0.56	0.01
Eng. listening	0.67	0.57	1.00	0.89	0.21
Eng. reading	0.77	0.56	0.89	1.00	0.23
Bebras	0.10	0.01	0.21	0.23	1.00

Table 6: Kendall  $\tau$  for grade 5 INVALSI and Bebras results (regions)

	Italian	Mathematics	Eng. listening	Eng. reading	Bebras
Italian	1.00	0.75	0.81	0.82	0.56
Mathematics	0.75	1.00	0.86	0.88	0.54
Eng. listening	0.81	0.86	1.00	0.95	0.58
Eng. reading	0.82	0.88	0.95	1.00	0.53
Bebras	0.56	0.54	0.58	0.53	1.00

Table 7: Kendall  $\tau$  for grade 8 INVALSI and Bebras results (regions)



Figure 2: Grade 5 comparison between Bebras (dashed) and INVALSI (solid) results at regional level. The mean Bebras result and its standard deviation are also shown in the graph title in brackets.

	Italian	Mathematics	Bebras
Italian	1.00	0.90	0.48
Mathematics	0.90	1.00	0.46
Bebras	0.48	0.46	1.00

Table 8: Kendall  $\tau$  for grade 10 INVALSI and Bebras results (regions)

proach used in INVALSI: to get numerically comparable results we used Normal distributions located in 200, with scale of 40. We adopted sensible prior parameter choices, common in the IRT literature, but we do not know if a difference considered significant in our model would be marked as such also by the INVALSI approach.

The main threat to validity, however, is the bias

intrinsic in the Bebras sample. While INVALSI data cover every school in Italy and the sample surveyed in [INV18] was supposedly chosen with statistical goals in mind, we just used all the data of the teams who participated to the last three editions of the Italian Bebras and were able to ship a result with our online platform [BCL<sup>+</sup>18]. Bebras pupils are thus drawn from the classes and schools with teachers interested in computational thinking and informatics (although this special interest is not necessarily shared by their pupils) and had the equipment and the logistic context suitable to participate. Also, while INVALSI tests individuals, Bebras is played in teams of 3–4 students.

For INVALSI we used the data as reported in [INV18], since we have no access to raw data. The data source is incomplete, for example no pieces of information are given about the numbers of sampled



Figure 3: Grade 8 comparison between Bebras (dashed) and INVALSI (solid) results at regional level. The mean Bebras result and its standard deviation are also shown in the graph title in brackets.

students by region or even macro-area. This makes it impossible to aggregate data in different ways with respect to the ones given or to put together INVALSI data related to different school years.

# 5 Conclusions

We can conclude that yes, the data of the last three editions of the Italian Bebras support the hypothesis that the general INVALSI national assessment of Italian schools can be used to predict the performance of students in the Italian edition of the Bebras International Challenge on Informatics and Computational Thinking. This result is not completely obvious, since Bebras avoids tasks based on curricular subjects and technical jargon and INVALSI assesses competencies in linguistic and mathematical areas, not directly ad-

dressed by Bebras. In fact, Italian schools do not have curricular informatics in grades 5 and 8. The national guidelines for primary and lower secondary schools somewhat mention computational thinking, but the adoption in school and its perception by teachers is rather discontinuous [CLN17a, CLN17b]. Even in grade 10, informatics appears only in vocational curricula and science oriented programs. A more coherent proposal is under discussion (see  $[FLL^+18]$ ), but currently we can safely assume that informatics and computational thinking are not routinely faced by the general population of Italian schools. Nevertheless, the Bebras snapshot seems to reflect the general geographic trend of Italian schools, even if the participants come from schools with a special interest in computational thinking and informatics. This could be an important result, because Bebras data can be



Figure 4: Grade 10 comparison among Bebras (dashed) and INVALSI (solid) results at regional level. The mean Bebras result and its standard deviation are also shown in the graph title in brackets.

used to assess the computational skills of the students and, according to our study, they have the potential to be generalized to a wider population.

# Acknowledgments

The authors wish to thank Federico Pedersini and Massimo Santini for discussing early drafts of this paper.

# References

[BCL<sup>+</sup>18] Carlo Bellettini, Fabrizio Carimati, Violetta Lonati, Riccardo Macoratti, Dario Malchiodi, Mattia Monga, and Anna Morpurgo. A platform for the Italian Bebras. In Proceedings of the 10th international conference on computer supported education (CSEDU 2018) — Volume 1, pages 350–357. SCITEPRESS, 2018. Best poster award winner.

- [BLM<sup>+</sup>15] Carlo Bellettini, Violetta Lonati, Dario Malchiodi, Mattia Monga, Anna Morpurgo, and Mauro Torelli. How challenging are Bebras tasks? an IRT analysis based on the performance of Italian students. In *Proceedings of ITiCSE* 2015, pages 27–32, Vilnius, Lithuania, July 2015. ACM.
- [CAC<sup>+</sup>18] Giuseppe Chiazzese, Marco Arrigo, Antonella Chifari, Violetta Lonati, and Crispino Tosto. Exploring the effect of a robotics laboratory on computational

	Italian	Mathematics	Eng. listening	Eng. reading	Bebras
Italian	1.00	0.80	0.89	0.80	0.40
Mathematics	0.80	1.00	0.89	1.00	0.20
Eng. listening	0.89	0.89	1.00	0.89	0.45
Eng. reading	0.80	1.00	0.89	1.00	0.20
Bebras	0.40	0.20	0.45	0.20	1.00

Table 9: Kendall  $\tau$  for grade 5 INVALSI and Bebras results (macro-areas)

	Italian	Mathematics	Eng. listening	Eng. reading	Bebras
Italian	1.00	0.80	0.95	0.80	0.80
Mathematics	0.80	1.00	0.95	1.00	1.00
Eng. listening	0.95	0.95	1.00	0.95	0.95
Eng. reading	0.80	1.00	0.95	1.00	1.00
Bebras	0.80	1.00	0.95	1.00	1.00

Table 10: Kendall  $\tau$  for grade 8 INVALSI and Bebras results (macro-areas)

	Italian	Mathematics	Bebras
Italian	$1.00 \\ 0.95 \\ 0.95$	0.95	0.95
Mathematics		1.00	1.00

Table 11: Kendall  $\tau$  for grade 10 INVALSI and Bebras results (macro-areas)

thinking skills in primary school children using the bebras tasks. In *Proceedings* of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality, TEEM'18, pages 25–30, New York, NY, USA, 2018. ACM.

- [CLN17a] Isabella Corradini, Michael Lodi, and Enrico Nardelli. Computational thinking in italian schools: Quantitative data and teachers' sentiment analysis after two years of programma il futuro. In Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education, pages 224–229. ACM, 2017.
- [CLN17b] Isabella Corradini, Michael Lodi, and Enrico Nardelli. Conceptions and misconceptions about computational thinking among italian primary school teachers. In Proceedings of the 2017 ACM Conference on International Computing Education Research, pages 136–144. ACM, 2017.
- [Dag10] Valentina Dagienė. Sustaining informatics education by contests. In Proceedings of ISSEP 2010, volume 5941 of Lecture Notes in Computer Science, pages 1–12, Zurich, Switzerland, 2010. Springer.

- [Des18] Prove INVALSI Marta Desimoni. 2018, chapter Le prove carta e matita per la rilevazione nazionale degli apprendimenti INVALSI 2018: aspetti metodologici. INVALSI, 2018.https://invalsi-areaprove.cineca. it/docs/2019/Parte\_II\_capitolo\_2\_ aspetti\_metodologici\_P&P\_2018.pdf.
- [DS16] Valentina Dagienė and Sue Sentance. It's computational thinking! bebras tasks in the curriculum. In Proceedings of ISSEP 2016, volume 9973 of Lecture Notes in Computer Science, pages 28–39, Cham, 2016. Springer.
- [FLL<sup>+</sup>18] Luca Forlizzi, Michael Lodi, Violetta Lonati, Claudio Mirolo, Mattia Monga, Alberto Montresor, Anna Morpurgo, and Enrico Nardelli. A core informatics curriculum for Italian compulsory schools. In Pozdniakov S. and Dagienė V., editors, Informatics in schools. fundamentals of computer science and software engineering. ISSEP 2018., volume 11169 of LNCS, pages 141–153. Springer, Cham, 2018.
- [GH06] Andrew Gelman and Jennifer Hill. Data analysis using regression and multilevel/hierarchical models. Cambridge university press, Cambridge, UK, 2006.
- [HCD11] Bruria Haberman, Avi Cohen, and Valentina Dagienė. The beaver contest: Attracting youngsters to study computing. In *Proceedings of ITiCSE 2011*, pages 378– 378, Darmstadt, Germany, 2011. ACM.
- [HM14] Peter Hubwieser and Andreas Mühling. Playing PISA with Bebras. In *Proceedings*

of the 9th WiPSCE, pages 128–129, New York, NY, USA, 2014. ACM.

- [HS85] Ronald K. Hambleton and H. Swaminathan. Item Response Theory: Principles and Applications. Springer-Verlag, Berlin, 1985.
- [INV18] INVALSI. Rapporto prove INVALSI 2018. Technical report, INVALSI, 2018. Only in Italian, available at https://www.invalsi.it/invalsi/ doc\_evidenza/2018/Rapporto\_prove\_ INVALSI\_2018.pdf.
- [KVC06] Graeme Kemkes, Troy Vasiga, and Gordon V. Cormack. Objective scoring for computing competition tasks. In Proceedings of 2nd ISSEP, volume 4226 of Lecture Notes in Computer Science, pages 230– 241, Berlin, Germany, 2006. Springer.
- [LMM<sup>+</sup>17] Violetta Lonati, Mattia Monga, Anna Morpurgo, Dario Malchiodi, and Annalisa Calcagni. Promoting computational thinking skills: would you use this Bebras task? In Proceedings of the international conference on informatics in schools: situation, evolution and perspectives (ISSEP2017), Lecture Notes in Computer Science, Cham, CH, 2017. Springer International Publishing AG. To appear.
- [SBS17] Suzanne Straw, Susie Bamford, and Ben Styles. Randomised controlled trial and process evaluation of code clubs. Technical Report CODE01, National Foundation for Educational Research, May 2017. Available at: https://www.nfer.ac.uk/ publications/CODE01.
- [Sta16] Stan Development Team. Stan modeling language users guide and reference manual version 2.19.0. http://mc-stan.org, 2016.