Changes in inequalities related to the COVID-19 pandemic

Elina Kilpi-Jakonen
University of Turku

Minna Tuominen
University of Turku

Alessandro Ferrara
WZB Berlin Social Science Center

Francesca Borgonovi
University College London / OECD

Mapineq deliverable D3.4

November 2024

Funded by the European Union

Suggested citation:

Kilpi-Jakonen, E., Tuominen, M., Ferrara, A., & Borgonovi, F. (2024). Changes in inequalities related to the COVID-19 pandemic. Mapineq deliverables. Turku: INVEST Research Flagship Centre / University of Turku. DOI: 10.5281/zenodo.14204806

Summary history		
Version	Date	Comments
1.0	22.10.2024	Manuscript for review
2.0	16.11.2024	Reviewed manuscript for submission

Mapineq – Mapping inequalities through the life course– is a three-year project (2022-2025) that studies the trends and drivers of intergenerational, educational, labour market, and health inequalities over the life course during the last decades. The research is run by a consortium of eight partners: University of Turku, University of Groningen, National Distance Education University, WZB Berlin Social Science Center, Stockholm University, Tallinn University, Max Planck Gesellschaft (Population Europe), and University of Oxford

Website: www.mapineq.eu

The Mapineq project has received funding from the European Union's Horizon Europe research and innovation programme under the grant agreement No. 101061645.

Acknowledgement:

This document was reviewed by Markus Jäntti (Stockholm University) and William Foley (National Distance Education University) as part of Mapineq quality assurance procedures. The content of the document, including opinions expressed and any remaining errors, is the responsibility of the authors.

Publication information:

Executive summary

Over the past decade, average school performance among 15-year-olds in OECD countries has been declining. During the COVID-19 pandemic, learning outcomes dropped more sharply than ever before in many countries. While in many countries the response to the pandemic, including the length of school closure varied across geographical areas, research has paid limited attention to sub-national changes in learning outcomes.

In this study, we assess differences in math, reading, and science learning trends in rural areas, towns and urban centers across OECD countries. We also examine whether pre-COVID preparedness for distance learning, in terms of ICT use and the number of digital devices available for students, or the length of school closures, are associated with the changes in sub-national differences.

We study trends among the entire student population, separately by gender, and for low SES students, using cross-sectional PISA-surveys from 2009 to 2022 and linear regression models, focusing on 15-year-old students. In line with previous literature, we find that urban students' average performance exceeds that of rural students. This is the case even after taking into account differences in students' socioeconomic characteristics. These differences are somewhat larger in reading scores than in math or science.

During the pandemic, schools were closed for an average of 5.5 months, or 22 weeks globally, leading to unprecedented learning losses of ¾ of a year in math and ½ a year in reading, while the average science score did not significantly change. Earlier research shows that the effect was strongest on boys and students from disadvantaged family backgrounds.

Our analysis of changes in 2022 results compared to the long-term (2009–2018) average indicates significant variation across countries. In the few countries where students in rural areas or towns were performing better than their peers in cities, the tended to decrease. Conversely, in many countries, though not all, where students in rural areas or towns were performing worse, the differences relative to their peers increased. However, many of the observed changes were not statistically significant.

Gender differences in the 2022 change were relatively small, and differences between low SES students and the overall student population did not reveal a clear trend. Contrary to our expectation, sub-national differences in ICT preparedness and the length of school closure were not substantially correlated with changes in test scores at the sub-national level.

In conclusion, there was substantial variation in how COVID-19 affected sub-national differences in learning outcomes, with several countries seeing pre-existing gaps between rural areas, towns and cities widen further. However, the reasons for the differential trends do not seem to be related to ICT preparedness or the duration of school lockdowns.

Funded by
the European Union

Abbreviations

OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
SES	Socio-Economic Status

Content

EXECUTIVE SUMMARY 3

ABBREVIATIONS 4

1. INTRODUCTION 8

2. PREVIOUS RESEARCH 8

2.1. SUB-NATIONAL DIFFERENCES IN LEARNING RESULTS 8
2.2. COVID-19 AND LEARNING INEQUALITIES 9
2.3. ICT USE AND LEARNING 11

3. RESEARCH QUESTIONS 12

4. DATA AND METHODS 12

4.1. PISA 2009–2022 12
4.2. METHODS 16

5. RESULTS 17

5.1. SUB-NATIONAL DIFFERENCES IN MATHS 17
5.2. SUB-NATIONAL DIFFERENCES IN READING 24
5.3. SUB-NATIONAL DIFFERENCES IN SCIENCE 30
5.4. RELATING ICT PREPAREDNESS WITH CHANGES IN SUB-NATIONAL DIFFERENCES 36
5.5. RELATING SCHOOL CLOSURES WITH CHANGES IN SUB-NATIONAL DIFFERENCES 38

6. CONCLUSIONS 38

REFERENCES 41

APPENDIX: REGRESSION RESULTS BY COUNTRY, SEX AND FOR LOW SES 44

Tables

TABLE 1. ICT PREPAREDNESS ACROSS COUNTRIES AND LEVELS OF URBANITY FOR THREE ICT MEASURES. 15
TABLE 2. SCHOOL CLOSURES IN DAYS ACROSS COUNTRIES AND LEVELS OF URBANITY. 16
TABLE 3. CORRELATION BETWEEN SUB-NATIONAL DIFFERENCE IN ICT PREPAREDNESS (HOMEWORK, AT SCHOOL AND DEVICES) WITH CHANGES IN SUB-NATIONAL DIFFERENCES IN TEST SCORES: RURAL–CITY (R–C) AND TOWN–CITY (T–C) COMPARISONS FOR ALL STUDENTS, GIRLS, BOYS AND LOW SES STUDENTS. 36
TABLE 4. CORRELATION BETWEEN SUB-NATIONAL DIFFERENCE IN LENGTH OF SCHOOL CLOSURES WITH CHANGES IN SUB-NATIONAL DIFFERENCES IN TEST SCORES: RURAL–CITY AND TOWN–CITY COMPARISONS FOR ALL STUDENTS, GIRLS, BOYS AND LOW SES STUDENTS. 38

TABLE A. 1. MEAN DIFFERENCES IN MATH SCORE ACROSS LEVELS OF URBANITY (REF. CITY) FOR POOLED 2009–2018 PISA ROUNDS AND THE CHANGE IN 2022. 44
TABLE A. 2. MEAN DIFFERENCES IN READING SCORE ACROSS LEVELS OF URBANITY (REF. CITY) FOR POOLED 2009–2018 PISA ROUNDS AND THE CHANGE IN 2022. 47

Funded by the European Union

Table A. 3. Mean differences in science score across levels of urbanity (ref. city) for pooled 2009–2018 PISA rounds and the change in 2022. 50

Figures

Figure 1. 2009–2018 mean in maths (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel). 18
Figure 2. 2022 difference in maths from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) (confidence intervals spanning over 110 have been capped). 19
Figure 3. 2009–2018 mean in maths (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels). 20
Figure 4. 2022 difference in maths from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels). 21
Figure 5. 2009–2018 mean in maths (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel) for low SES students. 22
Figure 6. 2022 difference in maths from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) for low SES students. 23
Figure 7. 2009–2018 mean in reading (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel). 24
Figure 8. 2022 difference in reading from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel). 25
Figure 9. 2009–2018 mean in reading (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels). 26
Figure 10. 2022 difference in reading from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels). 27
Figure 11. 2009–2018 mean in reading (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel) for low SES students. 28
Figure 12. 2022 difference in reading from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) for low SES students. 29
Figure 13. 2009–2018 mean in science (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel). 30
Figure 14. 2022 difference in science from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel). 31
Figure 15. 2009–2018 mean in science (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels). 32
Figure 16. 2022 difference in science from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels). 33
Figure 17. 2009–2018 mean in science (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel) for low SES students. 34
Figure 18. 2022 difference in science from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) for low SES students. 35
Figure 19. Difference in ICT use for homework (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel). 37

Funded by the European Union

Changes in inequalities related to the COVID-19 pandemic

Several empirical studies indicate that the COVID-19 pandemic has resulted in substantial learning losses among children and young people, partly due to school closures. We focus on one type of inequality which has received less attention in the literature on the educational consequences of the pandemic: changes in sub-national differences. In most countries, students in rural areas tend to have lower educational outcomes than their peers in towns or larger cities, a difference that can be explained, to a large extent, by differences in the socio-economic make-up of student populations in urban and rural areas. Different types of areas were differentially prepared to absorb the shock caused by school closures forcing instruction to move online: teachers were using ICT resources to varying extents and households were differentially equipped in terms of devices suitable for online access and connectivity. In some countries, school closures were also related to the local (rather than national) pandemic situation, meaning that rural schools experienced fewer/shorter closures than ones in cities. We examine whether there were changes in sub-national learning differentials after the pandemic and if so whether these changes were related to sub-national differences in ICT preparedness and/or the length of school closures. We use PISA data from 2009–2022, focusing on 2022 differences relative to 2009–2018 averages. We examine area differences after controlling for socio-demographic characteristics using linear regression models. We examine these questions for the whole student population, by gender, and separately for low SES students. Our results confirm that students in cities tend to have the highest learning results and those in rural areas the lowest, even after taking into account compositional differences. In many countries learning results declined the least following the pandemic in cities and the most in rural areas, but in some countries the gaps between areas diminished. While there were sub-national differences in ICT preparedness and school closures, these were not strongly related to changes between pre- and post-COVID19 in sub-national learning differences. Differences by gender or for low SES students relative to the whole population were not substantial.

In most OECD countries, students in cities have the highest learning results even after controlling for socio-demographic characteristics, and students in rural areas the lowest.

In some countries, differences between students in rural areas and their peers in cities widened in 2022, whereas in others they became smaller.

Changes in sub-national differences were not strongly related to differential ICT preparedness or the length of school closures.

Funded by the European Union

1. Introduction

Over the past decade, PISA-assessments of upper-secondary school students have revealed two central trends: a gradual decline in average achievement scores and significant disparities in these scores between countries (OECD, 2023). In OECD countries, average math and reading performance peaked in 2009 and 2012, respectively, after which both skills have been declining (OECD, 2023). Between the 2018 and 2022 PISA-survey rounds, learning outcomes dropped sharply in many countries, likely due to the COVID-19 pandemic.

Researchers worldwide have tracked the effects of the pandemic, and numerous studies—including single-country studies, systematic reviews, and meta-analyses—have reported negative changes in learning outcomes. While in many countries the response to the pandemic differed across sub-national areas (e.g. Schwartz et al., 2021; Shin et al., 2023), researchers have paid limited attention to within-country variation in learning outcomes. The few studies that have addressed this issue have yielded inconclusive results, possibly due to differing regional policies or school level preparedness to lockdowns (Clark et al., 2021; Kersha et al., 2023).

In this study, we explore sub-national differences in learning outcomes using cross-sectional PISA-surveys from 2009 to 2022. We focus on OECD member countries and define sub-national areas based on their level of urbanity. Specifically, we examine the extent to which 15-year-old students' performance in math, reading and science varies between rural areas, towns, and urban centres (cities) across these countries, assuming that the length of school closure and/or the level of digital device use for school work may relate to learning outcomes. We conduct the analyses for the whole student population, separately by gender, and for low SES students.

In 2015, on average, 49% of the population in OECD countries lived in cities, 24% in rural areas, and 26% in towns. However, these proportions vary substantially between countries. For example, in Korea, nearly 75% of the population lives in cities, while in Slovenia, 50% live in rural areas (OECD, 2022). Common characteristics of rural areas include low population density, cohesive and homogenous communities, and long distances between services, which affect both availability and costs of provisions (Echazarra & Radinger, 2019).

Our results show that across most countries, students in cities had the highest learning results even after controlling for socio-demographic characteristics, and students in rural areas the lowest. In many cases, differences between areas changed in 2022 compared to their longer-term averages. However, these changes varied between countries: in some countries the differences grew wider whereas in others they diminished. The changes were not found to be related to sub-national differences in ICT use in 2018 (measuring preparedness for distance learning during school closures) or sub-national differences in school closures. We do not find substantial gender differences or differential results for low SES students.

2. Previous research

2.1. Sub-national differences in learning results

Studies on within-country variation in learning outcomes provide a fragmented picture. For example, in Portugal, educational achievement varies only slightly across sub-national regions (Couto et al., 2020), while in Italy, as much as 50 % of the variation in educational outcomes can be explained by contextual or regional factors alone, particularly in reading skills (Matteucci & Mignani, 2014). The concept of region, however, varies between studies, with some focusing on local administrative divisions (such as 25 units in Portugal), others on larger areas of the country (such as North, Centre and South in Italy).

This research explores over-time variation in learning outcomes by sub-national areas defined according to their level of urbanity. Some past studies (Echazarra & Radinger, 2019; Kryst et al., 2015) indicate that in many countries, urban students' average performance exceeds that of rural students. However, there are countries like the United States, the United Kingdom and Belgium, where the opposite is true, and several other countries where no differences between urban and rural regions have been observed (Echazarra & Radinger, 2019).

Commonly, studies note that the apparent urban–rural divergence disappears after controlling for students' and schools' socioeconomic profile (Caro & Mirazchiyski, 2012; Echazarra & Radinger, 2019; Kryst et al., 2015). For example, Kryst et al., (2015) studied the urban–rural divide in eighth grade students' science achievement in five Post-Socialist countries in Eastern Europe. They found significant disadvantages for rural students in nearly all cases. However, after accounting for gender and family socioeconomic level, the disadvantage disappears in three countries but not in Hungary and Lithuania. Of the predictor variables, family socioeconomic background explained most of the variance.

Alongside school performance, educational expectations and tertiary education attainment also tend to be lower among rural students compared to their urban peers, and this gap is not fully explained by socioeconomic background (Boone & Van Houtte, 2016; Echazarra & Radinger, 2019). One possible explanation is labour market differentiation, which in urban areas typically demands higher-educated employees, whereas in rural areas, there is greater availability of low-wage and labour-intensive jobs (Roscigno & Crowley, 2001).

Nonetheless, rural schools have some notable advantages in terms of quality of education, including smaller classes and lower student-to-teacher ratios. These factors enable teachers in rural settings to provide more targeted support to students in need (Echazarra & Radinger, 2019), which could lead to better average learning outcomes compared to urban areas.

School level resources can be used to monitor system level inequalities. In a context of strong equity, no significant differences in resources should exist between schools (Matteucci & Mignani, 2014). Echazarra and Radinger (2019) show that while the average level of resource allocation in OECD countries does not substantially differ between urban and rural schools, there are notable between-country differences. For example, in Canada, Germany and Hungary, rural schools are better equipped, whereas in Australia, Ireland, Norway and Mexico, equipment is a cause of concern in rural schools. In most OECD countries, urban schools tend to be better equipped with science-specific resources, while rural schools tend to have more computers available for students (Echazarra & Radinger, 2019). Yet, in Eastern European countries, rural students are far less likely to possess or use a computer (Kryst et al., 2015).

2.2. COVID-19 and learning inequalities

During the COVID-19 pandemic, schools were closed, on average, for 5.5 months, or 22 weeks globally (Jakubowski et al., 2024). Numerous studies have concluded that school closures had a significant negative effect on students' learning outcomes (e.g. Di Pietro, 2023; Engzell et al., 2021; Hammerstein et al., 2021; Jakubowski et al., 2024).

Countries with shorter periods of school closure generally exhibited lower learning losses, whereas more substantial losses occurred in countries with longer periods of closure (Jakubowski et al., 2024). More precise estimates for the magnitude of this effect vary depending on the age of students, skills considered, data structure and country context, but studies covering multiple countries and continents often suggest an effect size around 0.2 standard deviations for the full period, or roughly 1 % of a standard deviation per week (Di Pietro, 2023; Patrinos, 2023). A recent meta-analysis (Di Pietro, 2023) indicates that average learning losses in European countries were less severe than in many other parts of the world. This may be due to various factors, including higher technological capability and lower level of household poverty.

Among different learning outcomes, the effect was more detrimental on mathematics skills compared to others (Betthäuser et al., 2023; Di Pietro, 2023; OECD, 2023). According to the PISA 2022 test results (OECD, 2023), the OECD average in math dropped by nearly 15 points (around 15% of a SD) and in reading by approximately 10 points (10% of a SD) compared to 2018. Considering that an average year of normal instruction for 15-year-old students yields a gain equivalent to 20 score points in PISA, the learning losses during the pandemic amount to ¾ of a year in math and ½ a year in reading (Avvisati & Givord, 2023; OECD, 2023). While scores were already declining before the pandemic, never before had the drop between two consecutive survey rounds exceeded 4–5 points. Meanwhile, the average science score did not exhibit significant change.

Jakubowski et al. (2024), compared the drop in 2022 to longer-term declining trends in maths, reading and science skills, and found that only in maths was the long-term trend linear. According to their calculations, between 2018 and 2020, the global math score dropped by 14 % of a standard deviation (corresponding to approximately seven months of learning). Due to the non-linear trend in science and reading, the effect of COVID-19-related school closure cannot be distinguished from the decline in the previous years (Jakubowski et al., 2024).

In addition to differences across types of skills, the effect of the pandemic was not uniform across all children. Jakubowski et al., (2024) found that learning losses varied by student's performance level and the duration of the closure. Among high-performing students, larger losses were observed in countries with long closures and low average achievement level, whereas for low-performing students, substantial losses occurred in contexts with short closures and high average achievement levels. At the same time, Hammerstein et al., (2021) suggest that school closures particularly affected low-performing children's math learning and high-performing children's reading skills.

Some researchers (Donnelly & Patrinos, 2022; e.g. Hammerstein et al., 2021; Schuurman et al., 2023) have found age group differences, with the effect being stronger on younger students. This could be due to younger children's greater need for adult guidance in the learning process and their greater sensitivity to pandemic-related stressors (Hammerstein et al., 2021). Meanwhile, older students, especially older girls, are better able to self-regulate their studies (Schuurman et al., 2023). While studies consistently point to a disproportionate effect of school closures on boys, the discussion about age group disparities remains inconclusive, as several large-scale studies (Di Pietro, 2023; Engzell et al., 2021) have not observed significant age-related differences, and others (Borgonovi & Ferrara, 2023) have observed even an improvement in such skills as reading among primary school students.

Funded by
the European Union

The negative effect of lockdowns was strongest on disadvantaged students from low-income and/or low-educated family backgrounds (Betthäuser et al., 2023; Engzell et al., 2021; Jakubowski et al., 2024; Schuurman et al., 2023). While a learning gap has long existed between better-off and worse-off students, COVID-19 deepened this gap (Betthäuser et al., 2023; Schuurman et al., 2023).

It has been suggested that children from low socioeconomic backgrounds may have limited access to parental support, school-provided assistance, adequate study space, and technological tools supporting remote learning – factors that proved especially important during the pandemic. By contrast, higher SES parents tend to have more resources to address their children's needs, providing them with more personal support, paid training courses, and better schools – all factors that reduced the vulnerability of children from advantaged household to pandemic-related disruptions (Hammerstein et al., 2021; Schuurman et al., 2023). It is also important to note that background-related challenges often intersect (e.g., low SES and migration background) (OECD, 2023). The more disadvantages a child is exposed to, the greater the harmful effects of a disadvantaged background (Evans et al., 2013). Under normal conditions, schools can to some extent compensate for differences in family support, but during school closures, such a compensatory effect is substantially reduced (Schuurman et al., 2023).

2.3. ICT use and learning

Digital inequalities have been conceptualised as different levels of digital divides: in terms of ICT or internet access (first level), ICT use and literacy (second level), and the outcomes of ICT use (third level) (Scheerder et al., 2017). The first level of the divide has become less relevant as internet access has become widespread, although there can still be differences in internet speed between households and areas. In the context of lockdowns during the pandemic, the number of devices with access to the internet in homes may have been an issue when several household members required access for school and work.

Research has highlighted how students, parents and teachers should have the necessary ICT skills to continue with schoolwork in the context of home schooling (Engzell et al., 2021). In cases where digital tools were already being used before the pandemic, research has shown that lockdowns did not affect learning results using these tools and in some cases results may also have improved (e.g., Meeter, 2021; Spitzer & Musslick, 2021; van der Velde et al., 2021).

Yet, several studies have highlighted social inequalities in students' ICT skills prior to the pandemic and have attempted to explain these. For example, analysing PISA 2018 data, Becker (2023) showed that social inequalities in ICT use for educational purposes at home are related to educational and ICT resources at home and students' motivations. Passaretta and Gil-Hernández (2023) found social inequalities in pupils' ICT skills to be mostly related to social inequalities in other (so-called hard) skills.

Notable between-school differences in ICT resources and use, as well as teacher competencies, have also been documented (Gerick, 2018; van de Werfhorst et al., 2022). These differences are influential for students' ICT skills (Gerick et al., 2017) but they do not necessarily explain social inequalities therein (Passaretta & Gil-Hernández, 2023) as they are not strongly linked to the student composition of schools, for example in terms of SES (van de Werfhorst et al., 2022). Nevertheless, schools' remote teaching provision, which included both online and offline elements, has been found to substantially explain social inequalities in time spent on learning at home during lockdowns (Bayrakdar & Guveli, 2023).

It should also be noted that previous research has shown that the use of ICT does not have a linear relationship with learning outcomes: whereas at low levels of ICT use, increases are associated with improved reading skills, at high levels of ICT use, increases are associated with reduced reading skills, leading to an inverted U-shape (Borgonovi & Pokropek, 2021).

3. Research questions

Against the backdrop of documented learning losses related to the COVID-19 pandemic, we focus on changes in sub-national differences relative to long-term averages. We examine learning trajectories in the three core competences measured in PISA: maths, reading and science. Due to known differences in socio-demographic characteristics between different urbanity levels, we take these characteristics into account in all our analyses and study differences and changes therein net of these. We examine whether pre-COVID preparedness for distance learning in terms of ICT use and number of digital devices available for students or the length of school closures are associated with the changes in sub-national differences.

We take into account two types of intersectionalities: sub-national differences by gender and sub-national differences by social origin. For the latter, we focus on students coming from low SES families. Due to the uneven distribution of students by SES sub-nationally, we have too few students in high SES groups to separately analyse sub-national differences among them. Nevertheless, a separate analysis for low SES students is warranted since they are at a greater risk of negative influences from the COVID-19 pandemic and the associated school closures.

Our research questions are:

1. Did the COVID-19 pandemic change the extent of learning differences at the sub-national level, namely between cities, towns and rural areas?
2. Were these changes related to differences in ICT preparedness or the length of school closures?
3. Were these trends and associations different across genders or for low SES students?

4. Data and methods

4.1. PISA 2009–2022

The Programme for International Student Assessment (PISA) is administered by the OECD to both OECD member countries as well as a range of countries or sub-national regions that are not part of the OECD. It has been running every three years since 2000, with a longer break of four years between the last two rounds due to the disruptions in education caused by the COVID-19 pandemic. We use data from the 2009, 2012, 2015, 2018 and 2022 rounds. Students are assessed in three core competencies in each round: maths, reading and science. In each cycle one of the three core assessment domains in measured in greater depth. This means that more testing time is dedicated to such domain, allowing to measure subcomponents defined both in terms of content and cognitive processes needed to solve specific tasks. The main assessment domain in 2022 this was maths. We analyse all three measures. PISA assessment scales are comparable over time. The mean was set to 500 and the standard deviation at 100 in the cycle for which a domain was first measured as the main domain (reading in 2000, mathematics in 2003 and science in 2006). Average scores have declined over time.

In this study we focus on OECD countries, defined as countries that were part of the OECD at the time of writing (38). At the same time, not all current OECD countries participated in PISA since 2009 or have valid information on key variables of interest. From our main analyses we drop countries where the information on level of urbanity is missing for all or at least crucial rounds (in particular 2018 and 2022) or there are no students in rural areas. This is the case for Costa Rica, Japan, Luxembourg, Norway, Sweden and Turkey. Some other countries are also dropped from further analyses, and this is described further below.

4.1.1. Sub-national differences in test scores

Our main focus is on sub-national differences in learning and changes therein. To assess sub-national differences, we define three levels of urbanity: cities, towns and rural areas. The information about the location of schools within these areas is obtained from the survey administered to the school principals. It is thus more reliable than if this were asked from students. The original survey asks this information in a slightly more detailed way, but for the purposes of this study, we collapse the original categories so that cities are defined as communities with over 100,000 inhabitants, towns with between 3,000–100,000 inhabitants, and rural areas as communities with fewer than 3,000 inhabitants.

4.1.2. Socio-demographic control variables

All the results that we present for sub-national differences in test scores control for the following key socio-demographic variables: gender, migration background, highest level of parental education, and highest level of parental occupational status (defined through the International Socio-Economic Index, ISEI, of occupational status).

4.1.3. ICT preparedness

We measure ICT preparedness from the PISA 2018 surveys. We test different specifications for this: ICT use for school-related work outside of school (homework for short), ICT use at school, and the number of digital devices in homes. The first two of these were asked in the additional ICT survey, which was not administered in Canada, Columbia, Germany, the Netherlands or Portugal so these countries are not part of the analyses where ICT preparedness is assessed.

ICT use for homework was asked with 12 items about the frequency of different types of ways in which digital devices were used outside of schools, including items such as doing homework on a computer or using email for communication with teachers. The answer categories ranged from never or hardly ever to every day. We recoded each of these to a binary variable differentiating at least once a week and less frequently. We then added up the number of ways digital devices were used at least once a week. Across the countries analysed, the mean was 5.0 (std. dev. 4.2). We then averaged this within countries at sub-national level. For the analyses, we calculated the difference between towns and cities as well as rural areas and cities.

ICT use at school was asked with 10 items about the frequency of different types of ways in which digital devices were used in schools, including items such as browsing the internet or using learning apps or learning websites. The answer categories were the same as for the homework items and we used the same recoding. Across the countries analysed, the mean was 3.2 (std.

dev. 3.3). This was also averaged within countries at the sub-national level. For the analyses, we calculated the difference between towns and cities as well as rural areas and cities.

These two ICT use measures thus essentially capture diversity in the use of ICT in and out of schools.

The digital devices at home indicator was derived using three items on the number of mobile phones with internet access, number of computers, and number of tablet computers. Each of these had four answer categories ranging from none to three or more. We added these together (although acknowledging that the answer categories are capped to three). Across the countries analysed, the mean was 5.8 (std. dev. 2.3). This measure was also averaged within countries at the sub-national level. For the analyses, we calculated the difference between towns and cities as well as rural areas and cities.

Table 1 displays these sub-national averages across the countries. For the two ICT use measures there was no clear pattern for sub-national differences. Although in many countries, ICT use was the most diverse in cities, followed by towns, and with rural areas being the least diverse, there were also a large number of countries that didn't follow this pattern and where ICT use was the most diverse in either towns or rural areas. This was particularly the case for the measure on ICT use at school. Overall, the size of the sub-national differences (i.e. the rural–city difference and the town–city difference) in the two ICT use measures correlated very highly (0.81 for rural–city and 0.91 for town–city). The large difference between rural areas and cities in Mexico, particularly with regard to ICT use for homework, stands out as an outlier, which could be due to measurement error, and thus Mexico was dropped from the analyses for rural–city differences when analysing ICT use. With regard to the number of digital devices at home, in the majority of countries students had the most devices in cities and the least in rural areas. However, there were also a number of countries where the most devices were found in either towns or rural areas.

Table 1. ICT preparedness across countries and levels of urbanity for three ICT measures.

	ICT use for homework			ICT use at school			Digital devices in homes		
	city	town	rural	city	town	rural	city	town	rural
AUS	5.2	4.5	4.1	3.9	3.4	3.1	6.8	6.8	6.3
AUT	4.2	4.2	3.5	n/a	n/a	n/a	6.4	6.4	6.2
BEL	3.4	3.6	2.9	1.8	2.2	1.2	6.3	6.8	6.5
CHE	3.4	3.6	3.7	2.4	2.2	2.5	6.5	6.6	6.9
CHL	4.2	4.0	4.4	2.6	2.6	3.3	5.1	4.7	4.5
CZE	4.3	4.0	3.6	3.3	2.9	2.6	6.2	6.1	5.9
DNK	5.4	5.2	4.2	4.6	4.6	3.9	7.6	7.7	7.7
ESP	3.8	3.8	3.5	2.2	2.2	1.8	6.3	6.1	5.9
EST	5.5	5.5	5.1	2.8	2.4	1.7	6.4	6.1	6.0
FIN	3.5	2.9	2.9	3.3	3.0	2.8	6.9	6.8	6.5
FRA	4.0	3.9	4.2	2.3	2.3	1.8	6.0	6.0	6.0
GBR	4.6	4.3	4.0	2.6	2.4	2.8	6.8	6.8	7.0
GRC	4.6	4.9	4.7	2.4	2.7	2.9	5.8	5.6	5.3
HUN	5.2	4.9	4.1	3.0	2.6	2.0	6.1	5.7	4.3
IRL	3.0	3.1	3.1	1.8	1.8	1.9	6.6	6.6	6.4
ISL	3.9	4.6	3.4	3.1	3.7	2.9	6.8	7.1	6.8
ISR	2.8	3.4	3.0	1.7	2.2	2.2	4.9	5.7	5.4
ITA	4.4	4.5	4.1	2.6	2.8	2.7	5.8	5.7	5.6
KOR	5.3	4.9	4.6	1.6	1.5	1.4	5.5	5.4	5.4
LTU	5.0	5.9	5.9	2.6	3.2	3.6	5.9	5.5	5.2
LVA	5.5	5.8	5.6	3.5	3.8	3.8	5.9	5.8	5.2
MEX	6.0	5.3	2.3	2.9	2.5	1.0	4.1	3.2	1.7
NZL	5.5	4.7	4.8	4.2	3.6	4.2	6.8	6.6	6.3
POL	5.6	5.6	5.9	3.4	3.5	3.6	6.1	5.9	5.6
SVK	4.8	4.8	4.2	3.0	3.2	2.6	6.4	5.8	5.0
SVN	4.3	4.9	4.0	2.3	2.9	1.9	6.2	6.1	6.0
USA	5.9	5.6	5.5	4.3	4.3	4.5	6.5	6.5	6.4

Note: PISA 2018 data, weighted averages (own calculations).

4.1.4. School closures due to COVID-19

The variable measuring school closures due to COVID-19 has been taken from the PISA 2022 student survey. Students were asked whether and for how long their school was closed due to COVID-19. The categories given to students were (1) No; (2) Yes, up to 1 month; (3) Yes, more than 1 month and up to 3 months; (4) Yes, more than 3 months and up to 6 months; (5) Yes, more than 6 months and up to 12 months; (6) Yes, more than 12 months. We created a continuous measure by assigning the mid-point value for all categories with ranges and the maximum/minimum values for the end categories. Table 2 displays the averages across countries and types of areas. In a number of countries schools in cities were closed for substantially longer than those in rural areas, with towns either close to cities or in-between. In some countries school closures were at the national level and thus there are no differences between areas. In very few countries (most notably South Korea), students in rural areas report their schools being closed for longer durations than those in more urban areas.

Funded by
the European Union

Table 2. School closures in days across countries and levels of urbanity.

	Cities	Towns	Rural areas
AUS	122	111	99
AUT	119	118	122
BEL	119	115	98
CAN	141	131	128
CHE	73	72	78
CHL	175	161	108
COL	222	204	208
CZE	179	172	172
DEU	167	163	132
ESP	104	106	108
EST	128	124	113
FIN	89	84	72
FRA	87	85	86
GBR	161	167	179
GRC	157	147	139
HUN	119	114	109
IRL	189	187	186
ISL	48	50	38
ISR	132	125	120
ITA	149	153	140
JPN	56	45	57
KOR	62	59	105
LTU	101	99	102
LVA	208	198	183
MEX	211	201	219
NLD	150	146	155
NZL	108	87	91
POL	157	145	153
PRT	103	101	103
SVK	152	142	147
SVN	129	127	135

Note: PISA 2022 data, weighted averages (own calculations).

4.2. Methods

We begin by estimating a model predicting the test score differences across the different levels of urbanity controlling for the socio-demographic background variables. We run these models separately by each country but pooling all the PISA rounds. Our preliminary analyses with separate analyses by country and round did not show clear over-time trends in how sub-national differences had developed, therefore we did not add a time trend to our analyses. However, we control for round in our analyses and introduce an interaction between the 2022 round and the urbanity measure. We therefore have a measure of the mean differences between cities and towns as well as cities and rural areas that pertains to the 2009–2018 rounds and a measure of how this changed in 2022, i.e. how 2022 differed from the 2009–2018 mean. We begin by showing results for both of these. In subsequent analyses, we focus on the 2022 change.

We ran the regressions for the whole student population, separately by gender and for low SES students. All the regressions were estimated with Stata 18 and the repest-command, which takes into account the plausible values, replication weights as well as sampling weights (Avvisati

& Keslair, 2014). In the text we show the results in graphs, and the appendix includes them in tables.

In order to assess whether differential ICT preparedness or school closures predict changes in sub-national differences, we correlate the relevant sub-national differences in these measures with the 2022 changes from the long-term average test score differences. We obtain estimates for sub-national differences in ICT preparedness and school closures from linear regressions using these as dependent variables and the urbanity measure as an independent variable, taking into account the sampling weights. We show the correlations for the whole student population, separately by gender and for low SES students.

Given that our results show overall rather weak correlations, we do not proceed with modelling these results further. Our preliminary tests of these models also do not suggest that this would bring about any further substantial insights on the matter.

5. Results

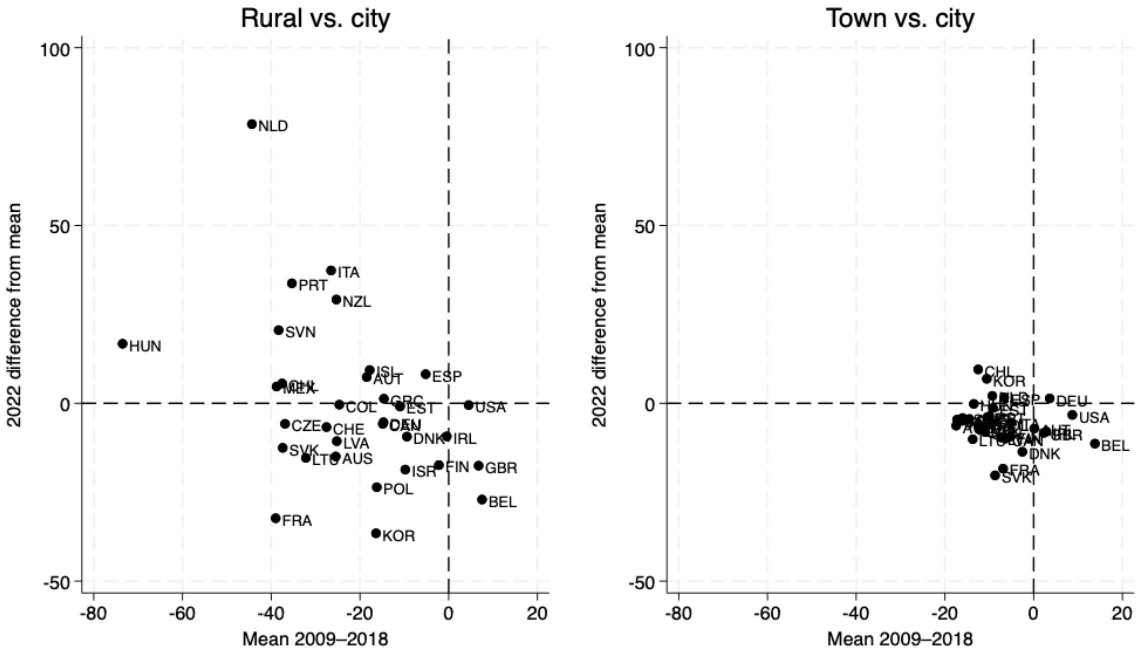
We first present the results for maths, then reading, and finally for science. Within each of these sections, we first present the results for all students, then separately by gender, and finally for low SES students.

5.1. Sub-national differences in maths

Figure 1 shows a scatter plot with the mean difference between rural areas and cities (in the left panel) and between towns and cities (in the right panel) on the x-axis. In most countries the mean is negative for both rural areas and towns, meaning that even after controlling for the basic compositional differences, students in these areas have lower maths scores than their peers living in cities. In a few countries, the mean is positive. On the y-axis of the graph is the 2022 difference from the 2009–2018 mean. Most countries have negative differences, meaning that maths scores in rural areas (or towns) fell further behind those of cities in 2022 (for the countries in the lower left quadrant) or positive differences diminished (in the lower right quadrant). However, there is also a number of countries where the previous negative differences were diminished or even reversed (in the upper left quadrant).

Funded by
the European Union

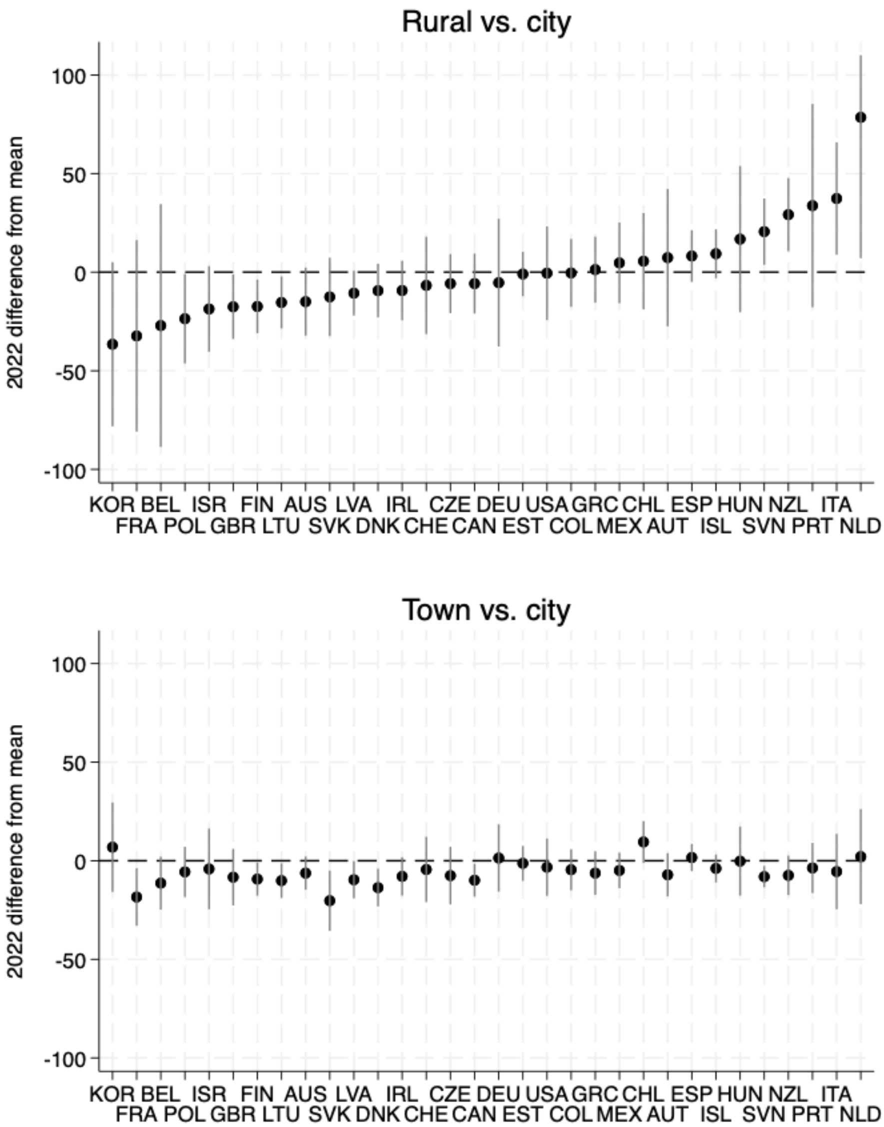
Figure 1. 2009–2018 mean in maths (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel).



Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Figure 2 focuses on the 2022 change from 2009–2018 mean, presenting this together with 95 % confidence intervals. Although there are slightly more countries where differences grew larger (or positive differences diminished) than countries where they became smaller, the only countries in which this negative change is statistically significant are Finland, Great Britain, Lithuania and Poland. Larger but not significant differences can also be seen for Belgium, France and South Korea. On the other side of the spectrum, the reduction in the difference (i.e. above zero) is statistically significant in Italy, the Netherlands, New Zealand and Slovenia. A relatively large positive but not significant change can also be seen in Hungary and Portugal. For the town–city comparison, almost all differences are negative. Although the differences are relatively small, they are statistically significant in Canada, Denmark, Finland, France, Lithuania, Latvia, Slovakia and Slovenia.

Figure 2. 2022 difference in maths from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) (confidence intervals spanning over 110 have been capped).



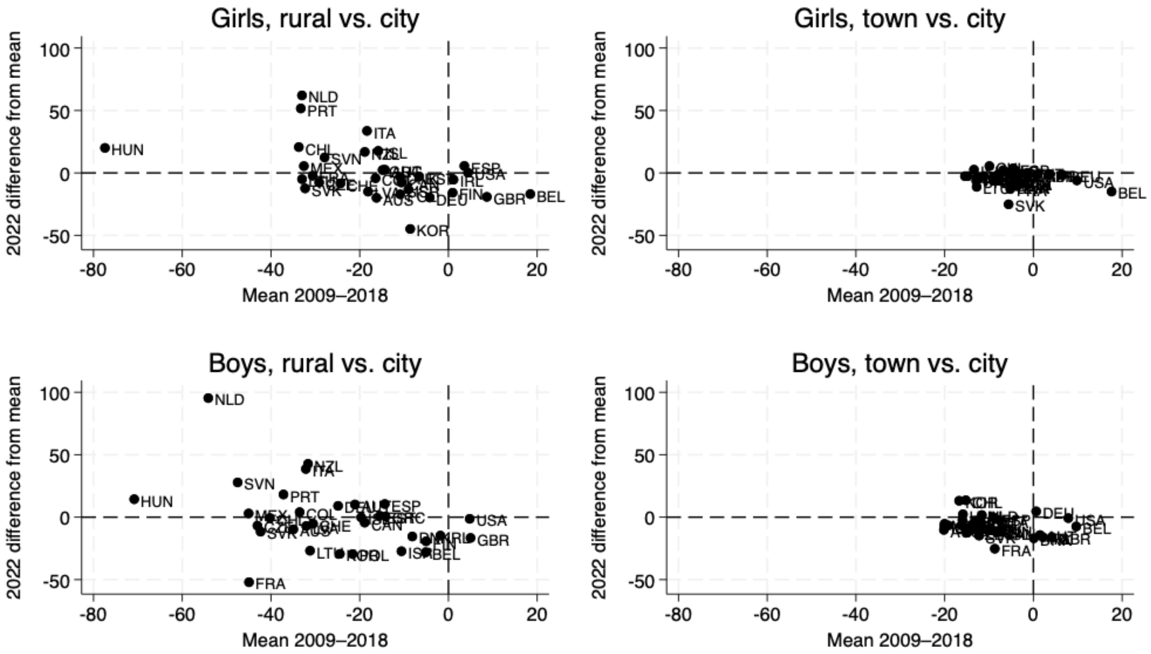
Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

5.1.1. Sub-national differences in maths by gender

Figure 3 presents the same scatter plots as in Figure 1 but divided by gender. While many of the basic patterns remain the same for both genders, it can be seen that the negative differences between rural areas and cities tend to be larger for boys than for girls, and there are more countries where the difference is positive for girls than for boys. Among both genders, the largest group of countries are in the lower left corner, with negative mean differences that grew larger in 2022.

Funded by
the European Union

Figure 3. 2009–2018 mean in maths (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels).

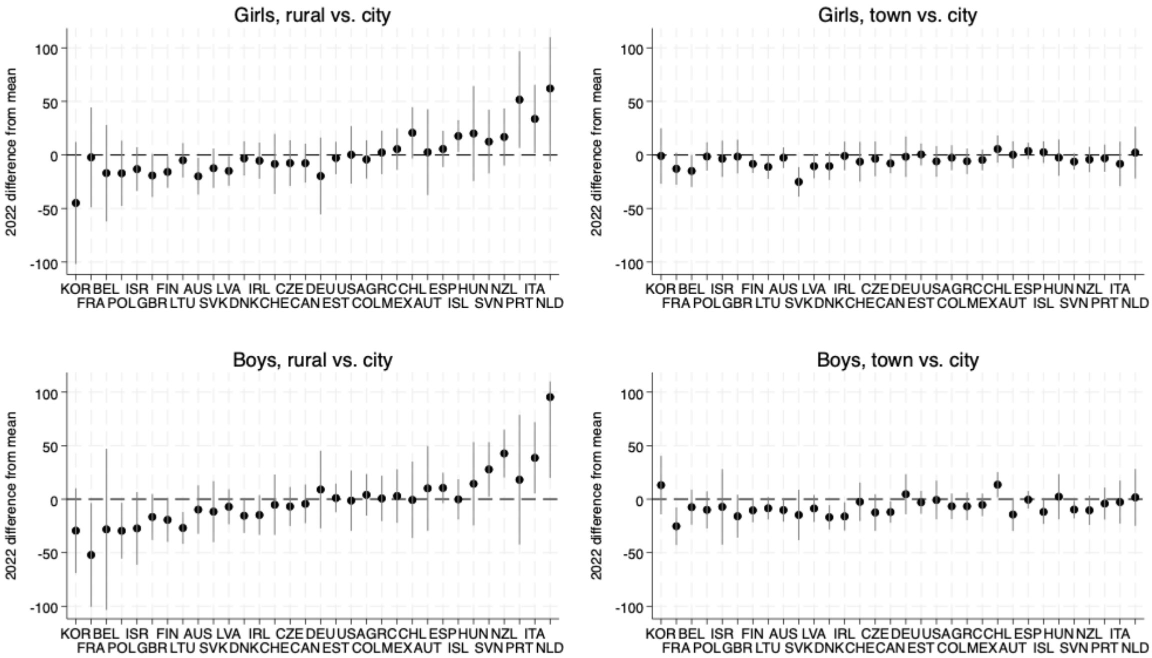


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Focusing on the 2022 changes, Figure 4 displays these together with the 95 % confidence intervals for both genders. In most cases, the differences are slightly larger for boys than girls for both the rural–city comparison as well as the town–city comparison. However, the gender difference in the changes is in most cases very small. Despite this, the countries that display statistically significant changes vary somewhat by gender. For the rural–city comparison, girls display significant negative changes in Australia, Finland and Latvia, whereas for boys this is France, Lithuania and Poland. In terms of positive rural–city 2022 changes (i.e. catching up in 2022), these are significant for girls in Iceland, Italy and Portugal, whereas they are positive for boys in Italy, the Netherlands, New Zealand and Slovenia. For the town–city comparison, the 2022 change is significant and negative for girls in Belgium and Slovakia, whereas this is the case for boys in Canada, Denmark, France, Ireland, Iceland and Slovenia. In terms of positive changes, there are no countries in which this catching up took place for girls and only Chile for boys.

Funded by
the European Union

Figure 4. 2022 difference in maths from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels).



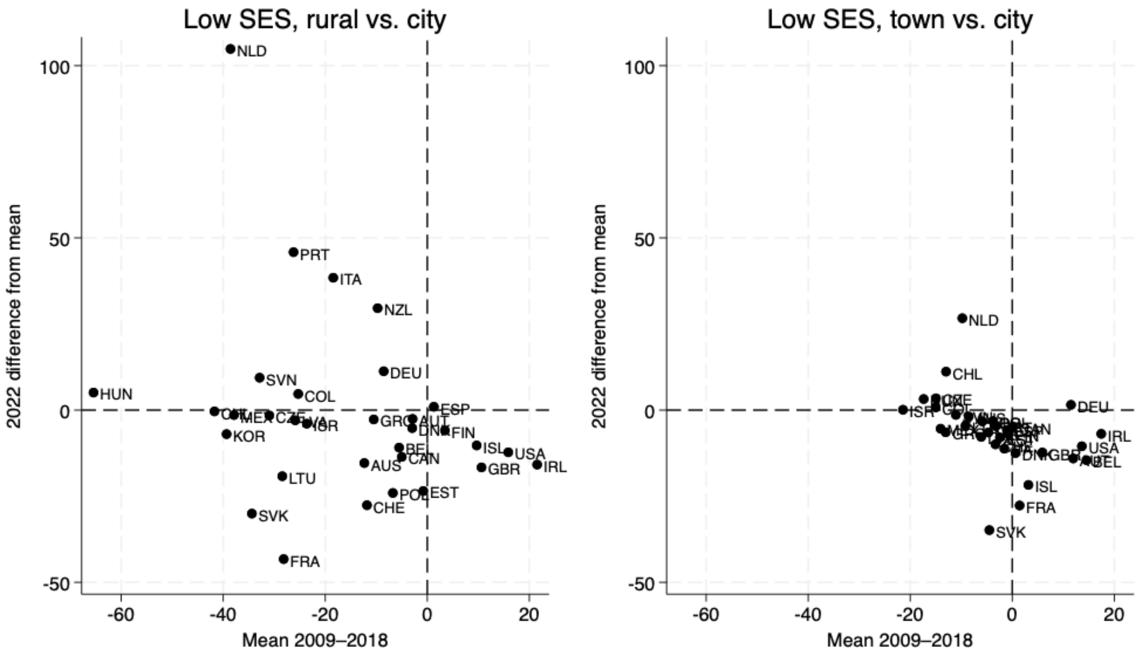
Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Funded by
the European Union

5.1.2. Sub-national differences in maths for low SES students

Figure 5 presents the same information as Figure 1 but for low SES students. Overall, the rural–city means tend to be slightly smaller for low SES students than for all students, and there are slightly more countries where the mean is positive for low SES students than for all students. The same applies for the town–city comparison. Similarly as for the whole population, the largest number of countries can be found in the lower left quadrant, where rural areas (or towns) had lower scores and this difference grew in 2022. There are slightly fewer countries that had lower scores in rural areas and catching up in 2022 (upper left quadrant) for low SES students compared to the whole population.

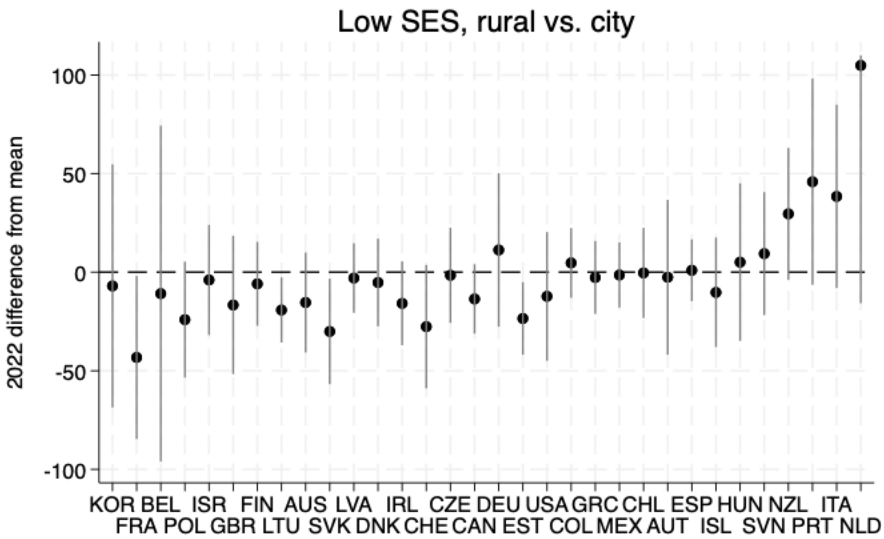
Figure 5. 2009–2018 mean in maths (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel) for low SES students.

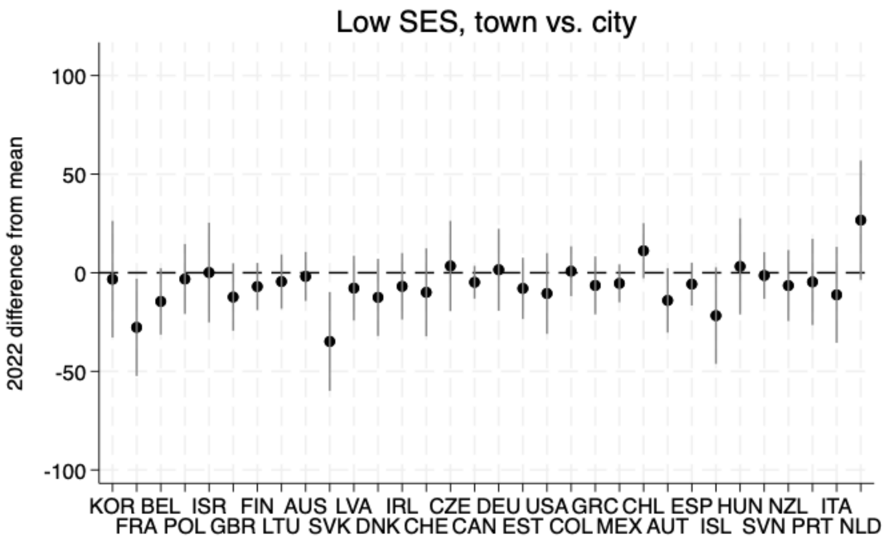


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Focusing on the 2022 changes from the previous mean in Figure 6, there is no clear trend in whether the 2022 changes were larger or smaller for low SES students than the whole population. In terms of statistical significance, for the rural–city comparison, the difference is statistically significant and negative in Estonia, France, Lithuania, and Slovakia, whereas for the town–city comparison this is the case in France and Slovakia. There are no countries with statistically significant positive changes, which would indicate catching up.

Figure 6. 2022 difference in maths from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) for low SES students.





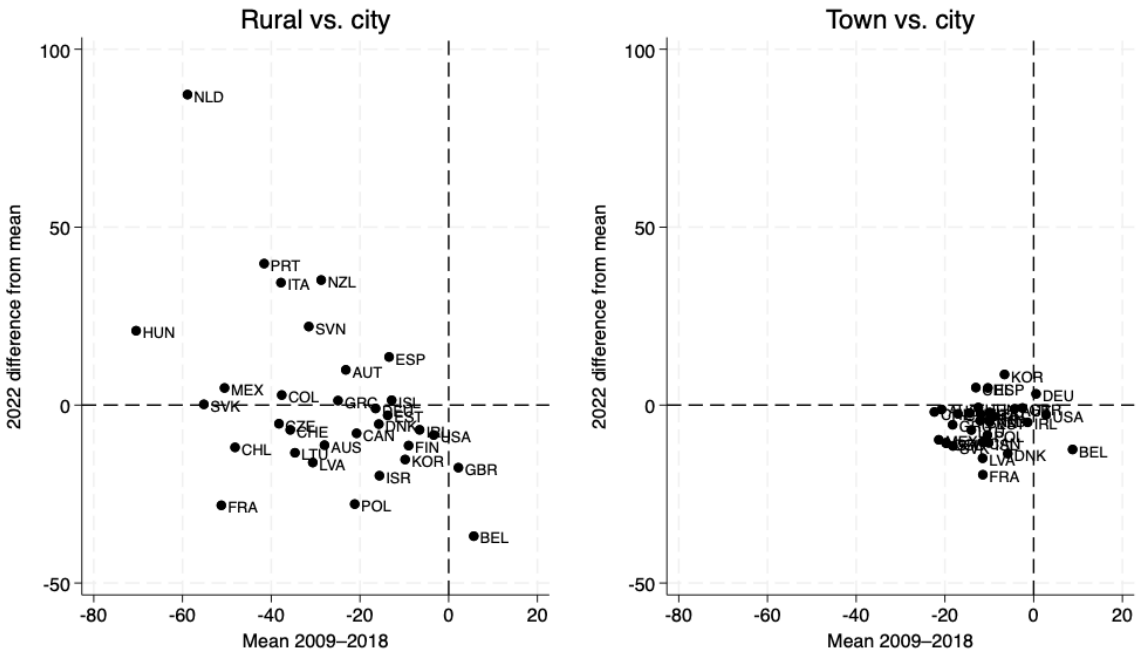
Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Funded by
the European Union

5.2. Sub-national differences in reading

We then turn to the results for reading. Figure 7 again shows the mean differences between areas on the x-axis, indicating that the vast majority of countries display the lowest reading scores in rural areas, followed by towns, even after controlling for compositional differences. These differences (particularly between rural areas and cities) also tend to be somewhat larger than the differences observed for maths scores. Only a few countries have higher reading scores in rural areas or towns compared to cities. Again, most countries are in the lower left quadrant with negative mean differences that grew larger in 2022 (particularly for the town–city comparison) but with a substantial number of countries also in the upper left quadrant with negative differences that were reduced or even reversed in 2022.

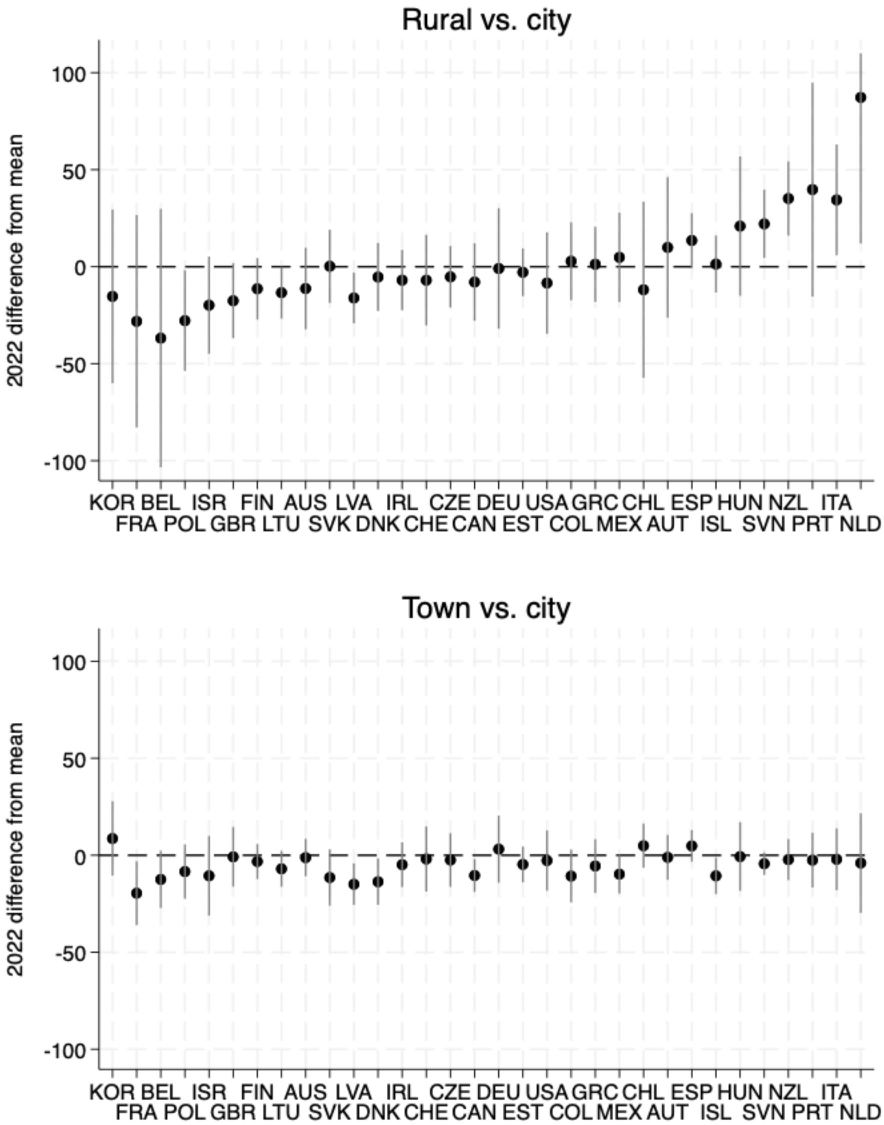
Figure 7. 2009–2018 mean in reading (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel).



Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Focusing on these 2022 changes from the previous mean, Figure 8 displays them together with their confidence intervals. On the whole, the picture is relatively similar to that for math (Figure 2), although the size of the differences tends to be slightly smaller for reading. The similarity of the rural–city comparisons can also be seen from the fact that the ordering of the countries from left to right has been set to that of the maths differences, and the countries follow this order relatively well also for reading. The only statistically significant negative changes for the rural–city comparison are for Lithuania, Latvia and Poland, although Belgium, France, Great Britain, Israel and South Korea also have quite large negative changes. The same countries as for maths have statistically significant positive changes: Italy, the Netherlands, New Zealand and Slovenia. Again Hungary and Portugal display relatively large positive but not significant associations. Although some of the town–city 2022 changes were positive, none of them were statistically significant, whereas on the side of the negative changes, the ones in Canada, Denmark, France, Iceland and Latvia were.

Figure 8. 2022 difference in reading from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel).

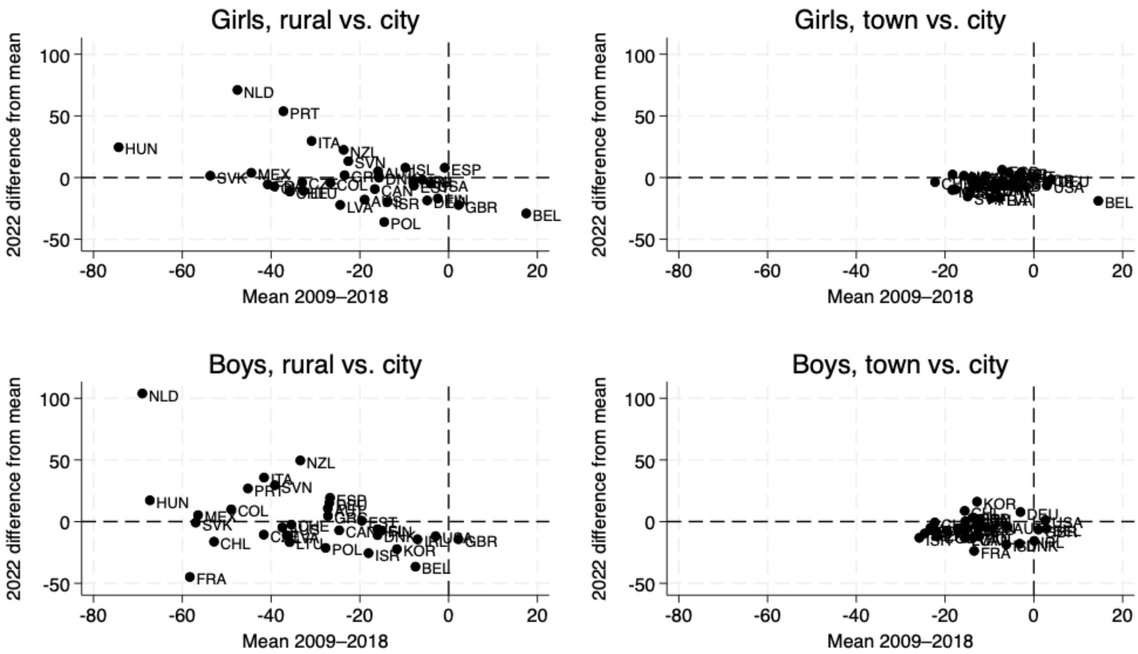


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

5.2.1. Sub-national differences in reading by gender

Figure 9 displays the mean sub-national differences in reading in 2009–2018 and the 2022 difference from this mean for girls and boys. As for maths, the rural–city mean difference tends to be larger for boys than for girls, and the same is the case for the town–city comparison although the mean differences are much smaller. There are an equal number of countries in the upper left quadrant of the rural–city comparison for both genders and they are mostly the same for boys and girls, though again there are slightly more countries in the lower left quadrant among boys.

Figure 9. 2009–2018 mean in reading (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels).

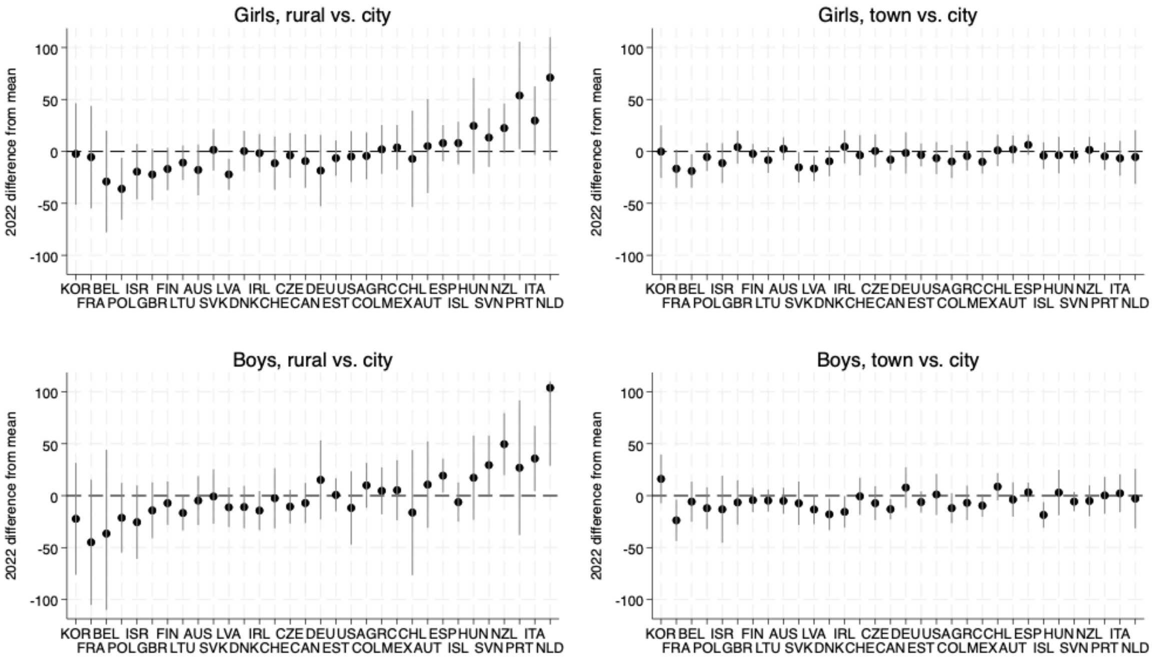


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Examining the 2022 changes in more detail, Figure 10 again shows that in most cases, girls and boys saw similar changes in sub-national differences. Nevertheless, there was variation in terms of the countries for which the differences were statistically significant. For the rural–city difference, this was significant and negative for girls in Latvia and Poland but not for boys in any country, whereas it was significant and positive for girls in Portugal and for boys in Spain, Italy, the Netherlands, New Zealand and Slovenia. Therefore, although there was catching up in an equal number of countries for both genders, this catch-up seems to have been more substantial for boys. For the town–city comparison, there were significant negative changes for girls in Belgium, Latvia and Slovakia, and for boys in Canada, Denmark, France, Ireland and Iceland, with no significant positive changes for either gender.

Funded by the European Union

Figure 10. 2022 difference in reading from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels).

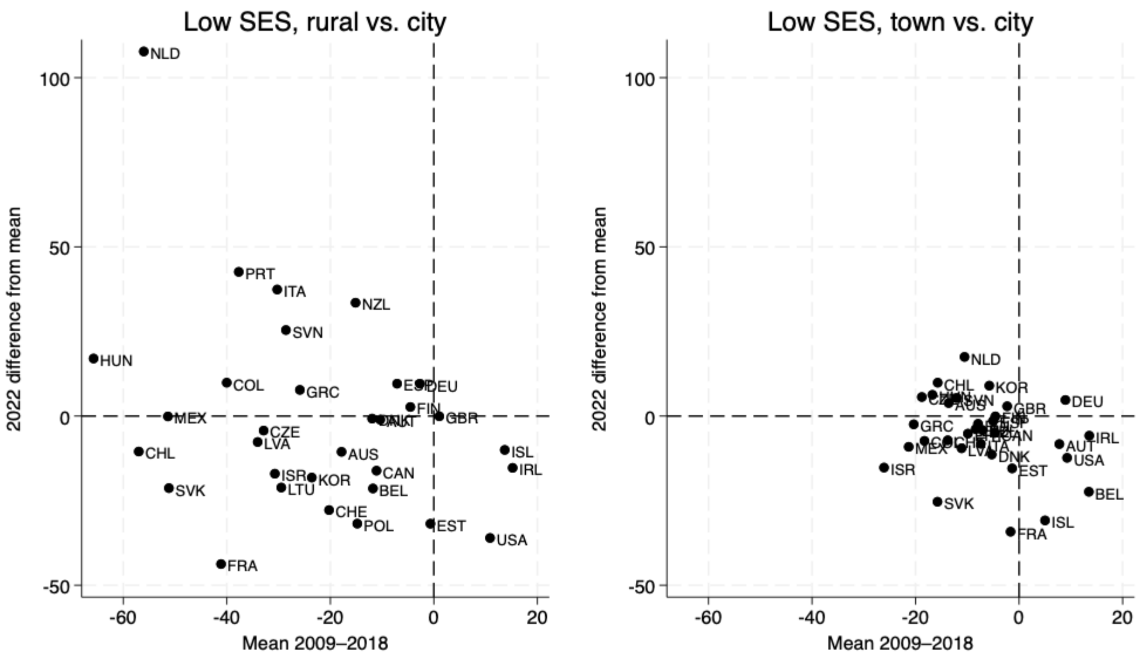


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

5.2.2. Sub-national differences in reading for low SES students

Figure 11 displays the mean sub-national differences in reading scores and the 2022 difference from the mean concentrating on low SES students. The picture remains much the same as that for the population as a whole (Figure 7) although the negative differences between the urbanity categories are slightly smaller for low SES students and somewhat more countries have positive mean differences. Once again, the largest number of countries can be found in the lower left quadrant of negative mean differences that were increased in 2022.

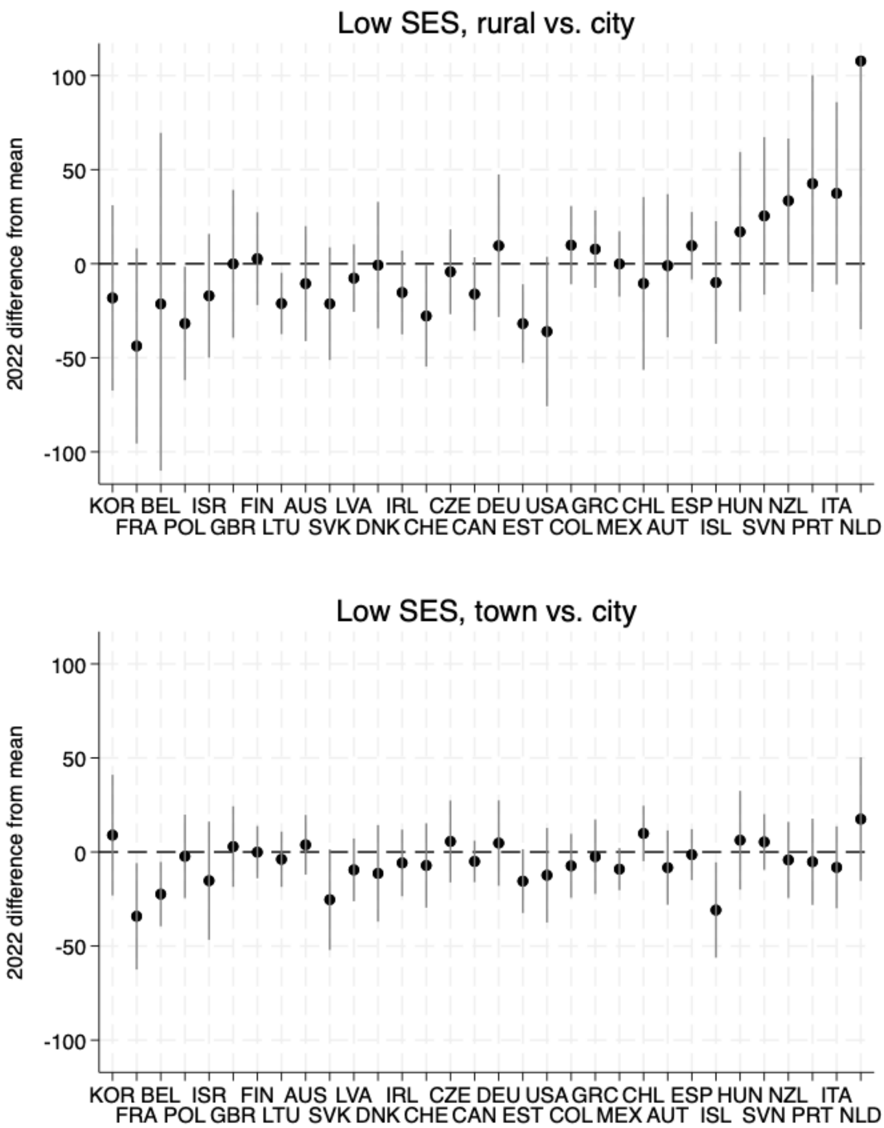
Figure 11. 2009–2018 mean in reading (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel) for low SES students.



Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Focusing on the size and statistical significance of the 2022 changes across countries, Figure 12 shows that there are quite a few countries where low SES students in rural areas fell further behind their peers in cities, though this is statistically significant only in Czechia, Estonia, Lithuania and Poland. In Belgium, France and Iceland, low SES students in towns also lost out statistically significantly in comparison with their peers in cities, although in all of these cases the differences were either positive or non-existent previously. The only statistically significant catching up was for rural students in New Zealand.

Figure 12. 2022 difference in reading from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) for low SES students.



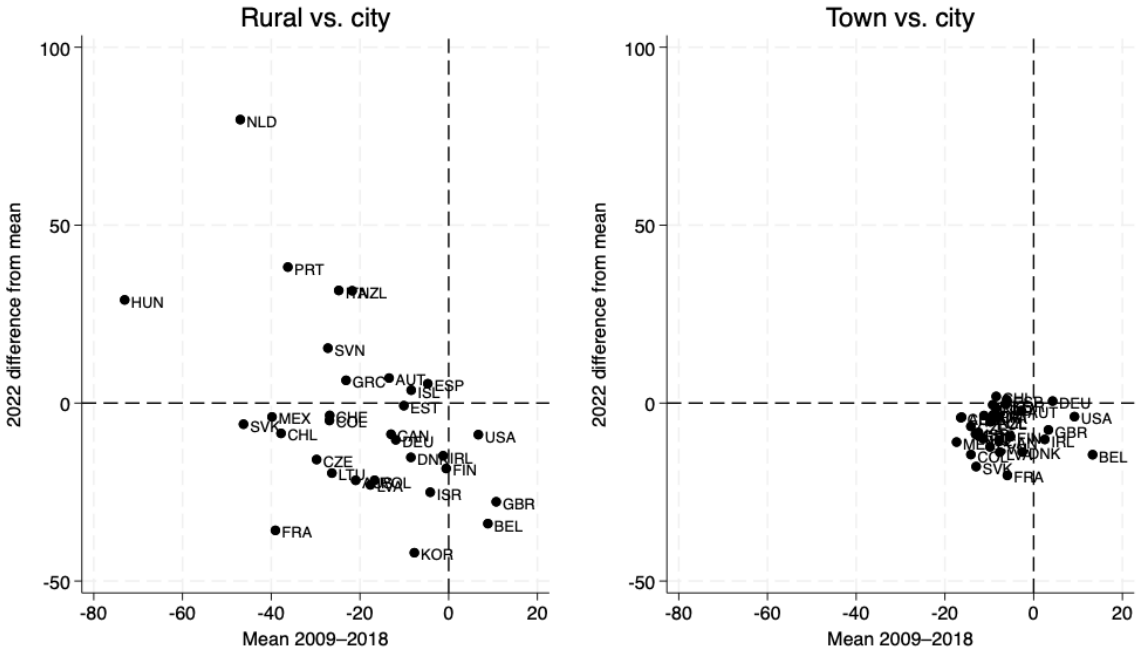
Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Funded by
the European Union

5.3. Sub-national differences in science

Figure 13 displays the 2009–2018 mean sub-national differences and the 2022 change for science scores. Overall, the picture is relatively similar to the one for maths. In other words, sub-national differences in science scores are not quite as large as those for reading scores. In terms of the mapping of the countries into the four quadrants: the distribution is largely similar to the previous ones.

Figure 13. 2009–2018 mean in science (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel).

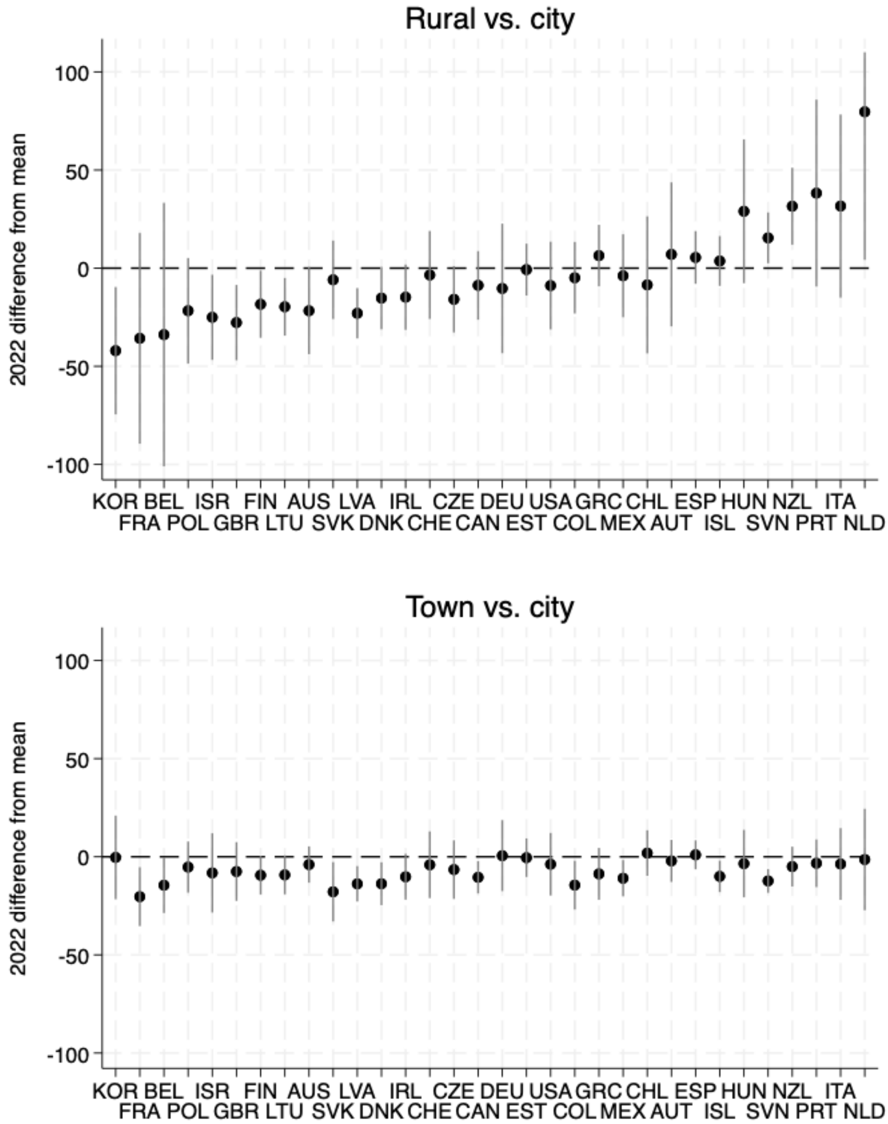


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Figure 14 displays the 2022 difference from the long-term mean for the two area comparisons. The ordering of countries is the one for the rural–city comparison in maths scores, and the countries seem to follow this ordering relatively well also for the rural–city comparison in science scores. The countries with significant and negative change are Finland, Great Britain, Israel, South Korea, Lithuania and Latvia, with Belgium, France and Poland also having a large but non-significant change. The countries with significant and positive change are the Netherlands, New Zealand and Slovenia, with positive and substantial but non-significant change also in Hungary, Italy and Portugal. The changes in the town–city comparison are much smaller in size but a number of the negative ones are statistically significant, namely the ones for Belgium, Canada, Colombia, Denmark, France, Iceland, Latvia, Mexico, Slovakia and Slovenia.

Funded by
the European Union

Figure 14. 2022 difference in science from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel).

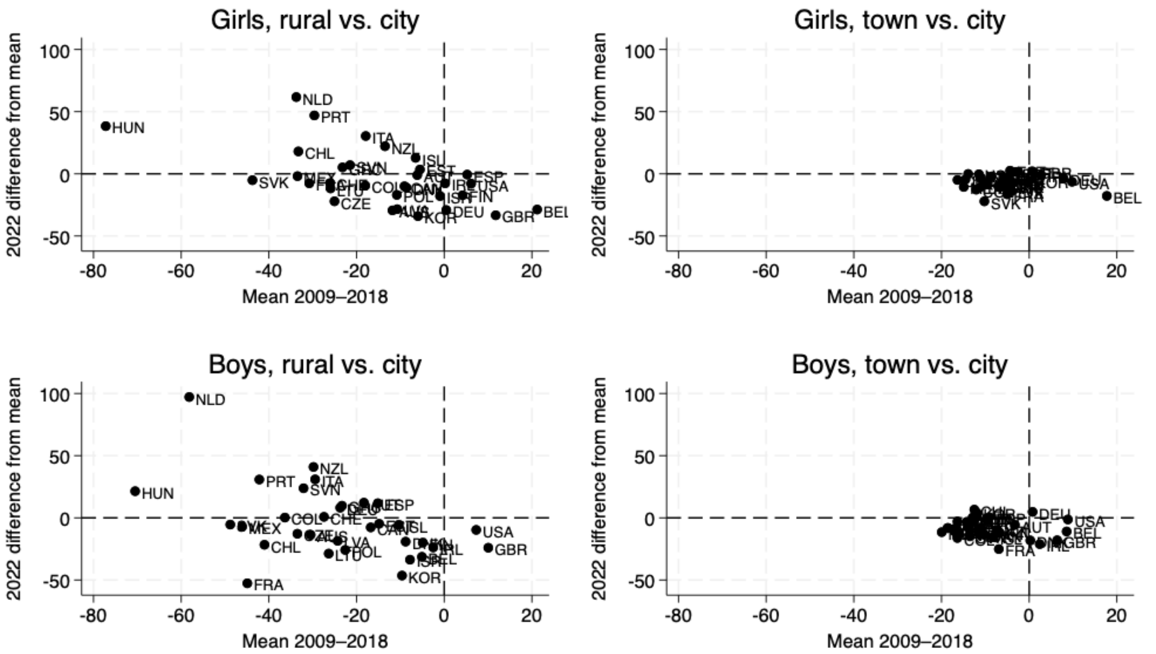


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

5.3.1. Sub-national differences in science by gender

Figure 15 presents the results for the mean sub-national differences in science scores and changes therein separately for girls and boys. As with maths and reading scores, the overall differences, particularly between rural areas and cities, tend to be larger for boys than for girls. There are also more countries in which students in rural areas have higher learning outcomes than those in cities among girls. Once again, all countries with positive differences saw these reduced or remain stable in 2022, whereas negative differences were in many cases increased and in some cases reduced.

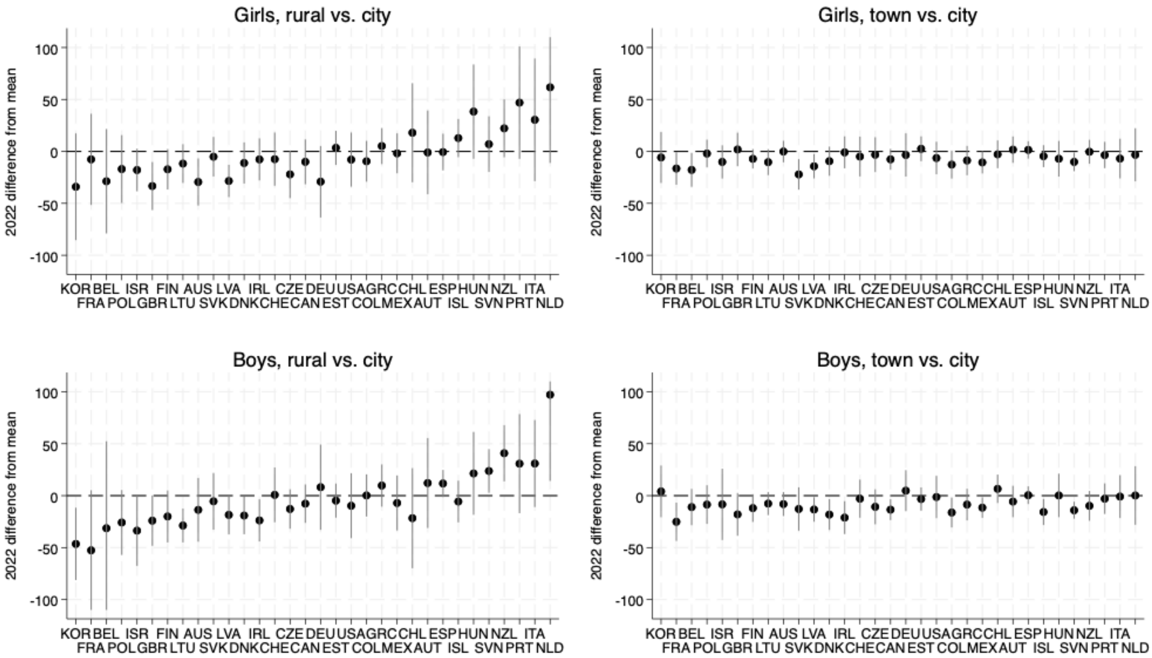
Figure 15. 2009–2018 mean in science (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels).



Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Figure 16 focuses on these 2022 changes. While gender differences are not particularly large, there is a slight tendency for there to be larger negative changes for boys than for girls. The countries in which the rural–urban change is statistically significant and negative for girls are Australia, Great Britain and Latvia, whereas for boys they are Denmark, Ireland, Soth Korea and Lithuania. There are no statistically significant and positive changes for the rural–urban comparison for girls, but for boys these can be found in the Netherlands, New Zealand and Slovenia. For the town–city comparison, statistically significant negative changes can be seen for girls in Belgium, France, Latvia, Slovakia and Slovenia, and for boys in Canada, Colombia, Denmark, France, Ireland, Iceland, Latvia, Mexico and Slovenia.

Figure 16. 2022 difference in science from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (left panels) and town–city comparison (right panels) for girls (upper panels) and boys (lower panels).

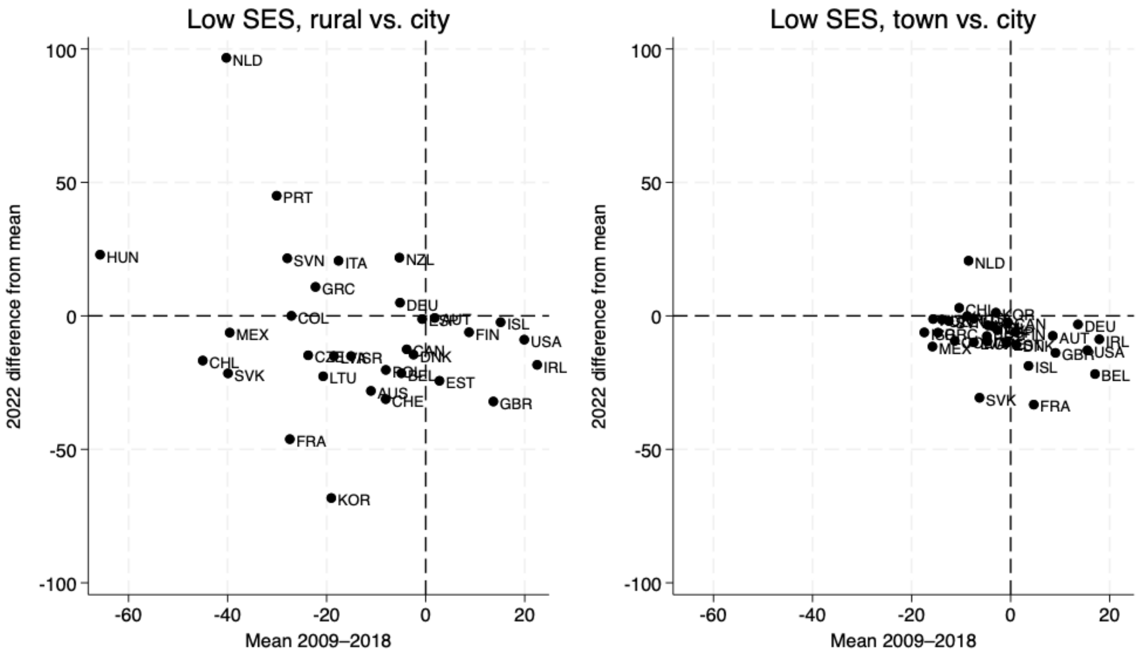


Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

5.3.2. Sub-national differences in science for low SES students

Moving to the analysis of low SES students, Figure 17 presents the long-term means between different types of areas and the 2022 differences from these means. Overall, the area-level differences tend to be slightly smaller (and slightly more are positive) than for the population as a whole. However, the 2022 changes seem to be slightly more negative (or less positive) than for the population as a whole.

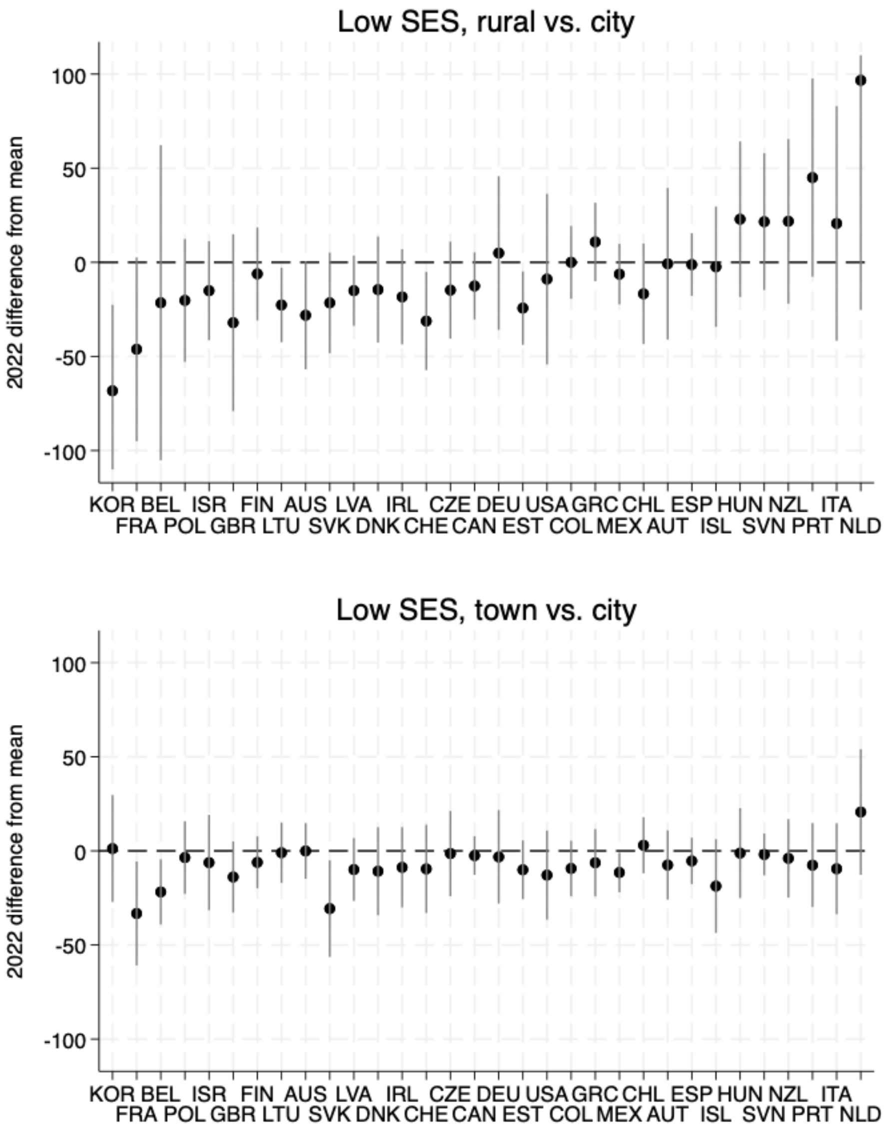
Figure 17. 2009–2018 mean in science (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel) for low SES students.



Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

These 2022 changes are the focus of Figure 18. None of the positive catching up changes are statistically significant for either rural areas or towns. In terms of negative changes, rural–city changes are significant in Czechia, Estonia, South Korea and Lithuania, and town–city changes are significant in Belgium, France, Mexico and Slovakia.

Figure 18. 2022 difference in science from the 2009–2018 mean with 95 % confidence intervals for rural–city comparison (upper panel) and town–city comparison (lower panel) for low SES students.



Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Funded by the European Union

5.4. Relating ICT preparedness with changes in sub-national differences

Table 3 shows the correlations between the aggregated sub-national difference in ICT preparedness, measured in 2018, and the 2022 change from the 2009–2018 mean sub-national differences in test scores. These correlations are calculated for all three measures of ICT preparedness and for all three competence measures. In addition, the correlations are calculated for all students, separately by gender, and for low SES students. It should be noted that in all cases, the measures of ICT preparedness represent those obtained from the whole population (at the sub-national level). On the whole, the correlations are quite weak: only two are above 0.4. There does not seem to be consistency or clear patterning in which ICT measure is the strongest. In many cases the correlations are stronger for reading than the other two competence measures. However, the most interesting thing to note is that almost all correlations are negative. This means, roughly, that the more rural areas were prepared in terms of ICT than cities, the greater the increase in the test score gap in 2022, whereas the less rural areas were prepared relative to cities, the more they caught up in 2022.

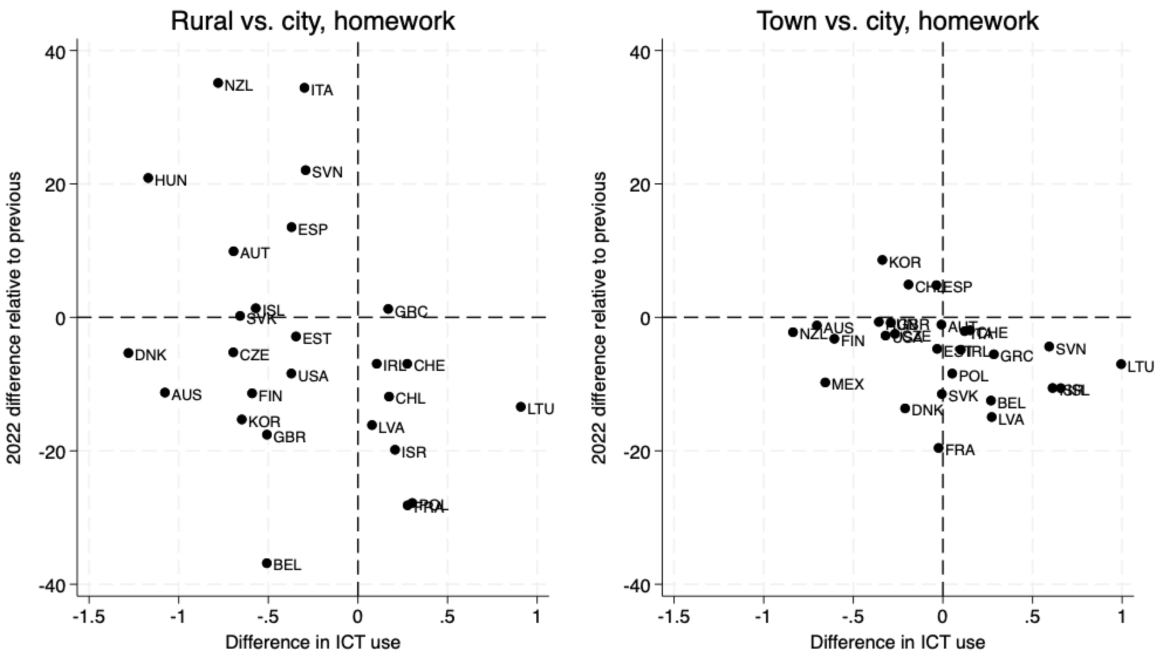
Table 3. Correlation between sub-national difference in ICT preparedness (homework, at school and devices) with changes in sub-national differences in test scores: rural–city (R–C) and town–city (T–C) comparisons for all students, girls, boys and low SES students.

	Math	Reading	Science
All			
R–C: homework	-0.22	-0.35	-0.24
R–C: at school	-0.02	-0.15	-0.10
R–C: devices	-0.28	-0.33	-0.33
T–C: homework	-0.14	-0.34	-0.26
T–C: at school	-0.19	-0.35	-0.37
T–C: devices	-0.09	-0.21	-0.12
Girls			
R–C: homework	-0.02	-0.35	-0.08
R–C: at school	0.04	-0.21	-0.05
R–C: devices	-0.26	-0.32	-0.35
T–C: homework	-0.14	-0.34	-0.31
T–C: at school	-0.26	-0.42	-0.46
T–C: devices	0.03	-0.13	-0.02
Boys			
R–C: homework	-0.32	-0.33	-0.32
R–C: at school	-0.07	-0.12	-0.13
R–C: devices	-0.26	-0.32	-0.28
T–C: homework	-0.11	-0.26	-0.13
T–C: at school	-0.10	-0.21	-0.15
T–C: devices	-0.21	-0.27	-0.20
Low SES			
R–C: homework	-0.31	-0.39	-0.20
R–C: at school	0.06	-0.06	-0.03
R–C: devices	-0.13	-0.22	-0.30
T–C: homework	-0.14	-0.32	-0.13
T–C: at school	-0.21	-0.31	-0.18
T–C: devices	-0.10	-0.30	-0.14

Note: Own calculations based on PISA 2009–2022.

This is exemplified further in Figure 19 which shows the sub-national differences in diversity of ICT use for homework together with the 2022 change in sub-national differences in reading scores for all students. In all countries in which rural areas (towns) had more diverse ways of using ICT for homework in 2018 than cities, the gap in reading test scores became larger (or a positive difference became smaller), whereas in all countries where rural areas caught up in terms of reading scores, they had less diverse ways of using ICT in 2018.

Figure 19. Difference in ICT use for homework (x-axis) and the 2022 difference from the mean (y-axis) for rural–city comparison (left panel) and town–city comparison (right panel).



Note: Own calculations based on PISA 2009–2022. Copyright 2024 by Kilpi-Jakonen et al.

Therefore, diversity of ICT use and the number of digital devices seem to be connected to within-country changes in learning outcomes during the pandemic only to a limited extent. The negative relationship that exists may be due to high levels of ICT use being associated with lower learning outcomes, as documented by previous research of the inverted-U-shaped relationship between ICT use and learning outcomes (Borgonovi & Pokropek, 2021).

Funded by
the European Union

5.5. Relating school closures with changes in sub-national differences

In Table 4, the correlations between the sub-national differences in school closures (in days) and the 2022 difference from the mean sub-national differences in test scores across the different populations and different competence measures are shown. In general these correlations are very low, all less than 0.3, and many of them are again negative, particularly for maths and science. For reading, most of the analysed correlations are positive, but none of them are greater than 0.2.

Table 4. Correlation between sub-national difference in length of school closures with changes in sub-national differences in test scores: rural–city and town–city comparisons for all students, girls, boys and low SES students.

	Math	Reading	Science
All			
Rural–city	-0.17	0.09	-0.08
Town–city	-0.02	0.14	0.08
Girls			
Rural–city	-0.22	0.16	-0.12
Town–city	0.10	0.19	0.18
Boys			
Rural–city	-0.15	0.02	-0.08
Town–city	-0.12	0.04	-0.05
Low SES			
Rural–city	-0.08	0.08	-0.24
Town–city	-0.24	-0.06	-0.14

Note: Own calculations based on PISA 2009–2022.

Therefore, despite cross-national variation in the length of school closures being related to learning losses, this does not seem to be the case within countries. One possibility for this is that the policy response to reduce the detrimental impacts of the pandemic were done in a way that balanced the length of school closures within countries.

6. Conclusions

We examined sub-national differences in learning outcomes and found substantial differences between rural areas, towns and cities even after taking into account compositional socio-demographic differences. In line with previous research (e.g., Echazarra & Radinger, 2019), we find that in most countries, test scores in rural areas tend to be the lowest and those in cities the highest, with larger differences in reading scores than in maths or science. In only a few countries the opposite pattern in terms of urbanity differences can be observed. Overall, urbanity differences tend to slightly larger among boys than among girls, and smaller for lower SES students than for the student population as a whole.

We then examined how these differences had changed in 2022 relative to their long-term (2009–2018) average. These changes, which are assumed to be largely due to COVID-19, were found to be extremely varied across countries. In countries where students in rural areas or towns were performing better, the differences relative to their peers in cities tended to become reduced. In some countries where students in rural areas or towns were performing worse, the differences relative to their peers were reduced whereas in others they became larger, with the largest number of countries falling into this latter category. However, not all of the changes were statistically significant; also, given the smaller number of students in rural areas than in towns, the estimates comparing rural areas to cities were less precise than those comparing towns to cities, and thus a larger number of changes are statistically significant for towns than for rural areas despite their smaller absolute values. Countries in which rural–city differences grew statistically significantly in at least two domains were Finland, Great Britain, Latvia, Lithuania and Poland. Countries in which town–city differences grew statistically significantly in at least two domains were Canada, Denmark, France, Iceland, Latvia, Slovakia and Slovenia. Countries in which significant catching up between rural areas and cities took place in at least two domains were Italy, the Netherlands, New Zealand and Slovenia.

In terms of gender differences, those in the 2022 change were relatively small, though there was a slight tendency for the differences to grow slightly more for boys than for girls in maths and science scores but this was less noticeable for reading scores. In Australia and Latvia, rural–city differences grew significantly larger for girls in at least two domains and in Lithuania for boys. Town–city differences grew significantly larger for girls in at least two domains in Belgium, Latvia and Slovakia, and for boys in Canada, Denmark, France, Ireland, Iceland and Slovenia. The rural–city gap was diminished in at least two domains for girls in Portugal and for boys in Italy, the Netherlands, New Zealand and Slovenia. Judging by these lists, it could be concluded that boys were influenced by the pandemic more heterogeneously than were girls.

There was no clear trend in whether the sub-national differences became greater for low SES students than for the student population as a whole. The countries in which the rural–city divergence grew significantly in at least two domains for low SES students were Czechia, Estonia and Lithuania. For the town–city divergence, this was Belgium, France and Slovakia.

Based on previous research (e.g. Di Pietro, 2023), it was expected that ICT preparedness could have played a role in explaining the changes in sub-national differences so that areas with less diverse regular ICT use or fewer devices with online access in families in 2018 would have seen greater within-country drops in test scores. However, correlations between ICT preparedness and changes in test scores at the sub-national level were overall rather weak. In almost all cases these correlations were in the opposite direction to that expected indicating that in areas where ICT preparedness was markedly weaker in rural areas or towns relative to cities, students in these areas caught up with their city peers, whereas the opposite was the case when their levels of preparedness were greater. It is possible that this could be related to the previously documented inverted-U-shaped association between ICT use and learning outcomes (Borgonovi & Pokropek, 2021).

Previous research has found school closures at the national level to have been associated with the extent of learning losses (Jakubowski et al. 2024). However, with regard to sub-national differences in school closures the same was the case as for ICT preparedness: the correlations with changes in test scores were very weak and many of them were also negative, although the ones for reading tended to be positive. One limitation of our research is that we have had to aggregate ICT preparedness and school closures to rather large areas within countries. More fine-grained measurement, for example at the school level or taking regional differences into account, could yield different results.

Funded by
the European Union

In conclusion, there was substantial variation in how COVID-19 affected sub-national differences in learning outcomes, with a number of countries seeing pre-existing gaps between rural areas, towns and cities widen further. The reasons for the differential trends do not seem to be related to schools' ICT use or the availability of digital devices in homes. Instead, these trends may be better explained by the marked diversity between rural and urban education systems across OECD countries already before the pandemic, as well as regional differences in overall level of development or regional policy. Increasing sub-national differences were most consistently noticeable in Central-Eastern and North-Western parts of Europe, with many other parts of the world – though limited to the OECD countries under study – seeing more limited sub-national change.

References

Avvisati, F., & Givord, P. (2023). The learning gain over one school year among 15-year-olds: An international comparison based on PISA. Labour Economics, 84, 102365. https://doi.org/10.1016/j.labeco.2023.102365

Avvisati, F., & Keslair, F. (2014). "REPEST: Stata module to run estimations with weighted replicate samples and plausible values," Statistical Software Components S457918, Boston College Department of Economics, revised 21 Mar 2024

Bayrakdar, S., & Guveli, A. (2023). Inequalities in Home Learning and Schools' Remote Teaching Provision during the COVID-19 School Closure in the UK. Sociology, 57(4), 767–788.

Becker, B. (2023). Social disparities in adolescents' educational ICT use at home: how digital and educational inequalities interact. In J. Skopek (Ed.), Research Handbook on Digital Sociology, pp. 293–306. Edward Elgar Publishing.

Betthäuser, B. A., Bach-Mortensen, A. M., & Engzell, P. (2023). A systematic review and meta-analysis of the evidence on learning during the COVID-19 pandemic. Nature Human Behaviour, 7(3), 375–385. https://doi.org/10.1038/s41562-022-01506-4

Boone, S., & Van Houtte, M. (2016). More Ambitious Educational Choices in Urban Areas: A Matter of Local Labor Market Characteristics? Urban Education, 51(8), 940–963. https://doi.org/10.1177/0042085914549363

Borgonovi, F., & Ferrara, A. (2023). COVID-19 and inequalities in educational achievement in Italy. Research in Social Stratification and Mobility, 83, 100760. https://doi.org/10.1016/j.rssm.2023.100760

Borgonovi, F., & Pokropek, M. (2021). The evolution of the association between ICT use and reading achievement in 28 countries. Computers and Education Open, 2, 100047.

Caro, D. H., & Mirazchiyski, P. (2012). Socioeconomic Gradients in Eastern European Countries: Evidence from PIRLS 2006. European Educational Research Journal, 11(1), 96–110. https://doi.org/10.2304/eerj.2012.11.1.96

Couto, A. P., Costa, P., & Ferrão, M. E. (2020). Territorial Differences in Student Performance in Portugal: The Role of Family Characteristics and School Composition. Revista Portuguesa de Estudos Regionais, 57, 89–103.

Di Pietro, G. (2023). The impact of Covid-19 on student achievement: Evidence from a recent meta-analysis. Educational Research Review, 39, 100530. https://doi.org/10.1016/j.edurev.2023.100530

Donnelly, R., & Patrinos, H. A. (2022). Learning loss during Covid-19: An early systematic review. PROSPECTS, 51(4), 601–609. https://doi.org/10.1007/s11125-021-09582-6

Echazarra, A., & Radinger, T. (2019). Learning in rural schools: Insights from PISA, TALIS and the literature (OECD Education Working Papers No. 196; OECD Education Working Papers, Vol. 196). https://doi.org/10.1787/8b1a5cb9-en

Engzell, P., Frey, A., & Verhagen, M. D. (2021). Learning loss due to school closures during the COVID-19 pandemic. Proceedings of the National Academy of Sciences, 118(17), e2022376118. https://doi.org/10.1073/pnas.2022376118

Evans, G. W., Li, D., & Whipple, S. S. (2013). Cumulative risk and child development. Psychological Bulletin, 139(6), 1342–1396. https://doi.org/10.1037/a0031808

Gerick, J. (2018). School level characteristics and students' CIL in Europe: A latent class analysis approach. Computers & Education, 120, 160–171.

Gerick, J., Eickelmann, B., & Bos, W. (2017). School-level predictors for the use of ICT in schools and students' CIL in international comparison. Large-Scale Assessments in Education, 5(1), 1–13.

Giménez, V., Thieme, C., Prior, D., & Tortosa-Ausina, E. (2019). Comparing the Performance of National Educational Systems: Inequality Versus Achievement? Social Indicators Research, 141(2), 581–609. https://doi.org/10.1007/s11205-018-1855-x

Hammerstein, S., König, C., Dreisörner, T., & Frey, A. (2021). Effects of COVID-19-Related School Closures on Student Achievement-A Systematic Review. Frontiers in Psychology, 12, 746289. https://doi.org/10.3389/fpsyg.2021.746289

Jakubowski, M., Gajderowicz, T., & Patrinos, H. (2024). COVID-19, School Closures, and Student Learning Outcomes. New Global Evidence from PISA. The World Bank Education Global Practice.

Kryst, E. L., Kotok, S., & Bodovski, K. (2015). Rural/urban disparities in science achievement in post-socialist countries: The evolving influence of socioeconomic status. Global Education Review, 2(4), 60–77.

Matteucci, M., & Mignani, S. (2014). Exploring Regional Differences in the Reading Competencies of Italian Students. Evaluation Review, 38(3), 251–290. https://doi.org/10.1177/0193841X14540289

Meeter, M. (2021). Primary school mathematics during the COVID-19 pandemic: No evidence of learning gaps in adaptive practicing results. Trends in Neuroscience and Education, 25, 100163. https://doi.org/10.1016/j.tine.2021.100163

OECD. (2022). OECD Regions and Cities at a Glance 2022. OECD. https://doi.org/10.1787/14108660-en

OECD. (2023). PISA 2022 Results (Volume I): The State of Learning and Equity in Education. OECD. https://doi.org/10.1787/53f23881-en

Passaretta, G., & Gil-Hernández, C. J. (2023). The early roots of the digital divide: socioeconomic inequality in children's ICT literacy from primary to secondary schooling. In J. Skopek (Ed.), Research Handbook on Digital Sociology, pp. 307–327. Edward Elgar Publishing.

Patrinos, H. A. (2023). The Longer Students Were Out of School, the Less They Learned. Journal of School Choice, 17(2), 161–175. https://doi.org/10.1080/15582159.2023.2210941

Roscigno, V. J., & Crowley, M. L. (2001). Rurality, institutional disadvantage, and achievement/attainment. Rural Sociology, 66, 268–292.

Scheerder, A. van Deursen, & J. van Dijk (2017). Determinants of internet skills, uses and outcomes: A systematic review of the second- and third-level digital divide. Telematics and Informatics, 34, 1607–1624.

Schuurman, T. M., Henrichs, L. F., Schuurman, N. K., Polderdijk, S., & Hornstra, L. (2023). Learning Loss in Vulnerable Student Populations After the First Covid-19 School Closure in the Netherlands. Scandinavian Journal of Educational Research, 67(2), 309–326. https://doi.org/10.1080/00313831.2021.2006307

Schwartz, H. L., Diliberti, M. K., Berdie, L., Grant, D., Hunter, G. P., & Setodji, C. M. (2021). Urban and Rural Districts Showed a Strong Divide During the COVID-19 Pandemic Results from the Second American School District Panel Survey. RAND Corporation. https://www.rand.org/pubs/research_reports/RRA956-2.html

Shin, C.-K., An, Y., & Oh, S. (2023). Reduced in-person learning in COVID-19 widens student achievement gaps in schools. Asia Pacific Education Review. https://doi.org/10.1007/s12564-023-09862-0

Spitzer, M. W. H., & Musslick, S. (2021). Academic performance of K-12 students in an online-learning environment for mathematics increased during the shutdown of schools in wake of the COVID-19 pandemic. PLOS ONE, 16(8), e0255629. https://doi.org/10.1371/journal.pone.0255629

van de Werfhorst, H. G., Kessenich, E., & Geven, S. (2022). The digital divide in online education: Inequality in digital readiness of students and schools. Computers and Education Open, 3(2022), 100100.

van der Velde, M., Sense, F., Spijkers, R., Meeter, M., & van Rijn, H. (2021). Lockdown Learning: Changes in Online Study Activity and Performance of Dutch Secondary School Students during the COVID-19 Pandemic. Frontiers in Education, 6: 712987.

Appendix: Regression results by country, sex and for low SES

Table A. 1. Mean differences in math score across levels of urbanity (ref. city) for pooled 2009–2018 PISA rounds and the change in 2022.

		Pooled 2009-2018 rounds				Interaction effect			
Country	Population	Town	Town (SE)	Rural area	Rural area (SE)	2022* town	2022* town (SE)	2022* rural	2022* rural (SE)
AUS	All	-17.5	1.9	-25.5	3.6	-6.3	4.3	-15.0	8.8
AUS	Female	-14.8	2.0	-16.2	4.0	-2.6	5.0	-19.9	8.8
AUS	Male	-20.2	2.4	-35.0	4.7	-10.2	5.5	-9.7	11.6
AUS	Low SES	-8.5	2.3	-12.3	5.4	-1.9	6.3	-15.4	12.9
AUT	All	0.1	3.6	-18.5	7.9	-7.1	5.6	7.4	17.8
AUT	Female	-1.3	3.9	-14.3	8.6	0.2	6.4	2.6	20.4
AUT	Male	1.5	5.1	-21.1	9.4	-14.3	7.8	10.1	20.2
AUT	Low SES	11.9	4.5	-2.9	8.3	-14.0	8.3	-2.6	20.0
BEL	All	13.8	3.7	7.5	10.3	-11.3	6.8	-27.1	31.4
BEL	Female	17.6	4.0	18.4	8.1	-15.0	7.6	-17.0	23.0
BEL	Male	9.7	4.4	-5.1	16.6	-7.4	8.4	-28.2	38.4
BEL	Low SES	14.5	4.0	-5.5	21.2	-14.5	8.6	-10.9	43.5
CAN	All	-6.3	2.0	-14.9	2.9	-9.9	4.2	-5.8	7.8
CAN	Female	-4.5	2.4	-10.6	3.4	-7.9	4.7	-7.7	9.2
CAN	Male	-8.1	2.3	-18.9	3.4	-12.0	5.1	-4.4	9.2
CAN	Low SES	0.2	3.1	-5.0	4.0	-4.8	4.2	-13.6	9.0
CHE	All	-14.5	5.1	-27.5	5.5	-4.4	8.4	-6.7	12.6
CHE	Female	-12.9	5.3	-24.3	6.3	-6.3	9.5	-8.4	14.3
CHE	Male	-16.0	6.0	-30.5	6.1	-2.5	9.1	-5.2	14.4
CHE	Low SES	-3.3	6.2	-11.8	7.6	-9.9	11.4	-27.6	15.9
CHL	All	-12.5	3.3	-37.6	6.4	9.5	5.4	5.6	12.4
CHL	Female	-9.9	4.2	-33.7	8.0	5.5	6.5	20.7	12.2
CHL	Male	-15.2	3.5	-40.3	8.8	13.6	6.0	-0.7	18.2
CHL	Low SES	-13.0	3.6	-41.7	8.0	11.2	7.1	-0.4	11.7
COL	All	-17.2	3.3	-24.7	4.2	-4.6	5.3	-0.4	8.8
COL	Female	-15.4	3.4	-16.4	4.4	-2.6	6.0	-4.2	9.1
COL	Male	-19.2	4.0	-33.5	5.2	-6.6	6.1	4.0	9.9
COL	Low SES	-15.0	3.6	-25.3	4.8	0.8	6.4	4.7	9.0
CZE	All	-12.0	3.7	-36.9	5.7	-7.5	7.5	-5.8	7.7
CZE	Female	-9.1	4.1	-29.1	6.9	-3.7	8.3	-7.6	10.9
CZE	Male	-14.9	5.0	-43.0	7.1	-12.4	8.7	-6.8	9.3
CZE	Low SES	-15.0	6.1	-31.0	8.2	3.4	11.7	-1.6	12.3
DEU	All	3.6	4.9	-14.7	12.4	1.4	8.7	-5.3	16.5
DEU	Female	6.6	5.3	-4.2	13.3	-1.7	9.6	-19.7	18.3
DEU	Male	0.6	5.5	-24.9	13.2	4.6	9.6	9.0	18.5
DEU	Low SES	11.5	5.9	-8.5	13.9	1.5	10.6	11.3	19.9
DNK	All	-2.5	2.6	-9.4	3.4	-13.6	4.9	-9.4	6.9
DNK	Female	-5.1	3.5	-10.9	4.0	-10.5	6.6	-3.2	8.1
DNK	Male	0.1	2.9	-8.1	4.2	-16.9	5.8	-15.5	8.2
DNK	Low SES	0.6	3.8	-3.0	5.1	-12.5	10.0	-5.2	11.3

Funded by the European Union

ESP	All	-6.6	1.5	-5.2	3.5	1.6	3.5	8.2	6.7
ESP	Female	-4.6	1.7	3.6	4.5	3.7	3.9	5.6	8.6
ESP	Male	-8.8	1.9	-14.3	4.0	-0.5	4.2	10.5	7.3
ESP	Low SES	-1.0	2.1	1.3	3.9	-5.8	5.5	1.0	8.0
EST	All	-9.2	2.3	-11.0	3.1	-1.3	4.5	-0.9	5.7
EST	Female	-5.5	2.5	-6.6	3.2	0.4	5.2	-2.9	7.7
EST	Male	-12.9	3.0	-15.4	3.8	-3.0	5.5	1.1	6.8
EST	Low SES	-2.4	3.8	-0.8	4.3	-8.0	7.9	-23.5	9.4
FIN	All	-5.2	2.2	-2.2	3.6	-9.3	4.3	-17.4	6.9
FIN	Female	-3.2	2.3	0.9	4.1	-8.4	4.3	-15.8	7.6
FIN	Male	-7.2	2.8	-5.0	4.6	-10.4	5.7	-19.3	10.5
FIN	Low SES	-0.7	4.1	3.5	5.2	-7.0	6.1	-5.9	10.9
FRA	All	-6.9	4.4	-39.0	9.4	-18.4	7.4	-32.3	24.8
FRA	Female	-5.2	4.5	-30.6	10.7	-12.9	7.6	-2.2	23.8
FRA	Male	-8.7	5.3	-44.9	10.2	-25.2	9.0	-52.1	24.7
FRA	Low SES	1.4	6.6	-28.1	10.0	-27.7	12.6	-43.3	21.1
GBR	All	2.3	3.4	6.7	5.3	-8.3	7.3	-17.6	8.3
GBR	Female	0.8	4.0	8.7	6.2	-1.5	8.0	-19.2	10.2
GBR	Male	4.2	4.7	5.0	6.0	-15.9	10.2	-16.6	11.0
GBR	Low SES	5.9	4.4	10.6	7.5	-12.3	8.7	-16.6	17.9
GRC	All	-12.5	3.2	-14.6	5.4	-6.3	5.6	1.3	8.5
GRC	Female	-9.1	3.2	-14.9	5.9	-5.9	6.1	2.3	10.4
GRC	Male	-16.1	3.9	-14.2	6.5	-6.6	6.6	0.7	10.8
GRC	Low SES	-13.1	4.5	-10.5	6.2	-6.4	7.5	-2.7	9.5
HUN	All	-13.5	4.4	-73.5	6.5	-0.2	8.9	16.7	18.9
HUN	Female	-11.2	4.4	-77.4	8.4	-2.5	8.6	20.0	22.7
HUN	Male	-15.9	5.0	-70.8	8.2	2.3	10.8	14.4	19.8
HUN	Low SES	-17.4	4.7	-65.4	8.1	3.2	12.4	5.1	20.4
IRL	All	2.9	2.3	-0.4	3.1	-7.9	5.0	-9.3	7.7
IRL	Female	3.7	2.6	1.1	3.8	-0.9	6.8	-5.4	8.6
IRL	Male	2.2	3.2	-1.8	4.0	-16.1	6.7	-14.8	9.5
IRL	Low SES	17.4	3.8	21.5	4.3	-6.9	8.6	-15.8	10.9
ISL	All	-10.4	1.8	-17.8	2.3	-3.9	3.6	9.3	6.3
ISL	Female	-13.4	2.5	-15.8	3.3	2.6	5.1	17.6	7.5
ISL	Male	-7.3	2.6	-19.7	3.7	-11.9	5.7	-0.1	9.6
ISL	Low SES	3.2	6.5	9.7	6.9	-21.7	12.5	-10.3	14.2
ISR	All	-16.0	3.8	-9.8	5.6	-4.1	10.4	-18.6	11.1
ISR	Female	-12.4	3.3	-9.0	5.1	-3.6	8.6	-13.2	10.5
ISR	Male	-20.0	6.0	-10.6	8.1	-7.2	18.0	-27.3	17.3
ISR	Low SES	-21.4	5.7	-23.6	9.3	0.1	12.9	-3.9	14.3
ITA	All	-5.0	3.5	-26.5	8.2	-5.5	9.7	37.3	14.6
ITA	Female	-2.3	3.9	-18.4	9.8	-8.4	10.6	33.6	16.3
ITA	Male	-7.6	4.1	-32.1	9.0	-2.7	10.2	38.6	17.0
ITA	Low SES	-1.6	4.2	-18.4	11.1	-11.2	12.4	38.4	23.7
KOR	All	-10.6	6.1	-16.4	19.7	6.9	11.6	-36.6	21.2
KOR	Female	-3.6	6.1	-8.6	23.9	-0.9	13.2	-44.9	29.1
KOR	Male	-16.7	8.3	-24.5	17.3	13.1	13.9	-29.4	20.2
KOR	Low SES	-5.9	7.8	-39.3	11.6	-3.3	15.1	-7.0	31.4
LTU	All	-13.7	2.7	-32.2	3.1	-10.1	4.5	-15.4	6.7
LTU	Female	-12.8	3.0	-33.0	3.6	-11.2	5.7	-5.0	8.2

Funded by
the European Union

LTU	Male	-14.8	3.3	-31.2	4.0	-8.5	5.3	-26.8	7.6
LTU	Low SES	-9.1	3.9	-28.4	3.9	-4.5	7.0	-19.2	8.4
LVA	All	-7.4	2.7	-25.2	3.5	-9.6	4.8	-10.7	5.8
LVA	Female	-3.7	3.4	-18.1	4.0	-10.5	5.8	-15.0	7.0
LVA	Male	-11.3	2.9	-32.0	4.4	-8.7	6.4	-7.0	8.4
LVA	Low SES	-6.1	4.0	-25.9	5.0	-7.8	8.4	-3.0	9.0
MEX	All	-16.1	2.3	-38.8	2.5	-4.9	4.6	4.7	10.4
MEX	Female	-12.4	2.5	-32.6	3.2	-4.6	5.0	5.5	9.9
MEX	Male	-20.0	2.5	-45.0	3.2	-5.3	5.4	3.0	12.8
MEX	Low SES	-14.0	2.4	-37.9	2.7	-5.4	4.9	-1.4	8.4
NLD	All	-9.3	6.2	-44.4	23.2	2.1	12.3	78.5	36.4
NLD	Female	-6.8	6.1	-33.0	20.5	2.2	12.4	62.1	34.7
NLD	Male	-11.6	6.9	-54.1	26.8	1.7	13.6	95.4	38.5
NLD	Low SES	-9.8	9.1	-38.6	25.1	26.7	15.4	104.9	61.5
NZL	All	-11.1	2.5	-25.3	5.8	-7.4	5.1	29.2	9.5
NZL	Female	-12.5	3.0	-18.9	6.4	-4.3	6.1	16.8	13.6
NZL	Male	-9.8	3.1	-31.6	7.4	-10.4	7.0	42.7	11.4
NZL	Low SES	-4.7	5.1	-9.7	8.2	-6.5	9.2	29.6	17.0
POL	All	-9.3	3.0	-16.2	3.0	-5.6	6.5	-23.6	11.6
POL	Female	-8.1	3.4	-10.9	3.6	-1.5	6.8	-17.1	15.5
POL	Male	-10.7	3.8	-21.6	3.9	-10.0	8.9	-29.5	13.3
POL	Low SES	-3.8	4.0	-6.7	3.9	-3.2	9.1	-24.1	15.0
PRT	All	-10.0	3.4	-35.3	9.3	-3.6	6.5	33.7	26.3
PRT	Female	-8.2	3.4	-33.3	10.1	-3.1	6.5	51.6	23.0
PRT	Male	-11.8	4.3	-37.2	9.9	-4.1	7.6	18.2	30.9
PRT	Low SES	-3.2	5.4	-26.2	10.2	-4.7	11.1	45.8	26.7
SVK	All	-8.7	4.5	-37.4	4.8	-20.3	7.8	-12.5	10.1
SVK	Female	-5.6	4.8	-32.3	5.8	-25.2	7.1	-12.4	9.4
SVK	Male	-12.2	5.4	-42.3	6.3	-14.7	12.0	-11.6	14.5
SVK	Low SES	-4.5	5.7	-34.4	6.2	-34.8	12.8	-30.1	13.6
SVN	All	-11.0	1.8	-38.3	6.4	-8.1	2.8	20.6	8.6
SVN	Female	-8.4	2.3	-27.9	9.7	-6.3	3.8	12.4	15.2
SVN	Male	-13.6	2.5	-47.5	8.9	-9.7	4.2	27.8	13.0
SVN	Low SES	-11.0	3.1	-32.9	9.1	-1.4	6.0	9.4	15.9
USA	All	8.7	3.1	4.5	4.7	-3.3	7.4	-0.5	12.1
USA	Female	9.8	3.4	4.4	5.0	-6.0	7.3	0.2	13.7
USA	Male	7.9	3.7	4.8	5.9	-0.7	9.2	-1.3	14.4
USA	Low SES	13.6	3.9	15.9	6.8	-10.5	10.4	-12.3	16.7

Funded by
the European Union

Table A. 2. Mean differences in reading score across levels of urbanity (ref. city) for pooled 2009–2018 PISA rounds and the change in 2022.

		Pooled 2009-2018 rounds				Interaction effect			
Country	Population	Town	Town (SE)	Rural area	Rural area (SE)	2022* town	2022* town (SE)	2022* rural	2022* rural (SE)
AUS	All	-20.7	2.0	-28.0	3.7	-1.2	4.9	-11.3	10.7
AUS	Female	-18.3	2.2	-18.9	4.0	2.5	5.6	-17.9	12.5
AUS	Male	-23.3	2.3	-37.5	4.9	-5.0	6.4	-4.7	12.0
AUS	Low SES	-13.6	2.9	-17.8	5.8	3.8	8.1	-10.6	15.6
AUT	All	-4.3	3.3	-23.2	8.0	-1.1	5.9	9.9	18.5
AUT	Female	-3.4	3.5	-15.9	9.0	1.9	6.8	5.1	23.1
AUT	Male	-6.1	5.1	-27.2	9.4	-3.8	8.4	10.6	21.2
AUT	Low SES	7.8	4.8	-10.4	8.4	-8.3	10.1	-1.1	19.4
BEL	All	8.8	3.8	5.7	9.5	-12.5	7.5	-36.8	34.0
BEL	Female	14.5	4.0	17.5	7.9	-18.9	8.2	-29.1	25.0
BEL	Male	2.9	4.7	-7.5	14.6	-5.8	9.8	-36.5	41.2
BEL	Low SES	13.5	4.6	-11.8	20.1	-22.4	8.7	-21.4	46.4
CAN	All	-11.5	1.9	-20.8	2.8	-10.4	4.3	-7.9	10.2
CAN	Female	-9.5	2.0	-16.6	3.5	-7.9	5.2	-9.3	13.1
CAN	Male	-13.7	2.3	-24.7	3.2	-13.0	5.0	-7.1	9.9
CAN	Low SES	-4.7	2.9	-11.1	4.2	-5.0	5.6	-16.1	10.0
CHE	All	-22.4	4.5	-35.7	5.0	-1.9	8.5	-7.0	11.9
CHE	Female	-22.3	4.7	-35.8	5.6	-3.7	9.8	-11.4	13.2
CHE	Male	-22.3	5.1	-35.4	5.6	-0.7	9.1	-2.4	14.8
CHE	Low SES	-13.8	6.3	-20.2	7.6	-7.2	11.5	-27.8	13.7
CHL	All	-13.0	3.0	-48.2	6.0	4.9	5.8	-11.9	23.2
CHL	Female	-10.7	3.5	-39.3	8.3	1.0	7.7	-7.2	23.6
CHL	Male	-15.6	3.5	-52.9	7.6	8.7	6.7	-16.3	30.7
CHL	Low SES	-15.7	3.4	-57.0	7.1	9.9	7.5	-10.5	23.5
COL	All	-19.7	3.9	-37.6	5.1	-10.7	7.0	2.8	10.2
COL	Female	-17.7	4.0	-26.6	5.5	-9.7	8.1	-4.3	11.5
COL	Male	-21.8	4.5	-49.0	5.9	-12.0	7.4	9.9	11.0
COL	Low SES	-18.3	4.4	-40.0	6.1	-7.3	8.7	9.9	10.6
CZE	All	-17.1	3.4	-38.3	5.4	-2.5	7.0	-5.2	8.1
CZE	Female	-13.9	3.8	-33.0	6.3	0.4	8.1	-3.9	11.0
CZE	Male	-19.6	4.8	-41.6	6.7	-7.2	8.3	-10.6	8.3
CZE	Low SES	-18.8	6.1	-32.9	7.8	5.6	11.1	-4.3	11.5
DEU	All	0.5	4.6	-16.5	11.0	3.2	8.8	-0.9	15.8
DEU	Female	4.0	4.9	-4.8	13.1	-1.5	10.1	-18.5	17.5
DEU	Male	-3.0	5.2	-26.9	10.9	7.8	9.9	15.2	19.4
DEU	Low SES	8.9	6.1	-2.7	13.0	4.7	11.6	9.6	19.3
DNK	All	-5.8	2.7	-15.7	3.2	-13.6	6.1	-5.3	8.9
DNK	Female	-8.5	3.7	-15.7	4.2	-9.5	7.3	0.3	9.9
DNK	Male	-3.2	3.0	-16.0	3.6	-18.0	7.7	-11.0	10.4
DNK	Low SES	-5.3	3.6	-11.9	5.5	-11.4	13.1	-0.8	17.2
ESP	All	-10.3	2.0	-13.4	3.7	4.8	4.1	13.5	7.2
ESP	Female	-7.1	2.3	-0.9	4.2	6.3	4.9	8.0	8.9
ESP	Male	-13.6	2.5	-26.7	4.9	3.3	4.7	19.3	8.3

Funded by the European Union

ESP	Low SES	-5.0	3.6	-7.1	4.4	-1.4	6.9	9.6	9.1
EST	All	-9.9	2.6	-13.8	3.2	-4.7	4.7	-2.9	6.3
EST	Female	-4.5	2.7	-7.8	3.4	-3.4	5.6	-6.5	8.7
EST	Male	-15.3	3.2	-19.6	4.1	-6.1	5.3	0.7	8.1
EST	Low SES	-1.3	4.1	-0.7	4.7	-15.5	8.6	-31.8	10.7
FIN	All	-9.0	2.2	-9.0	3.9	-3.2	4.6	-11.4	8.1
FIN	Female	-7.1	2.3	-2.4	4.6	-2.3	4.7	-16.9	10.5
FIN	Male	-11.0	2.9	-15.1	4.9	-4.3	6.0	-7.2	10.6
FIN	Low SES	-4.6	4.7	-4.5	6.3	-0.1	7.1	2.7	12.6
FRA	All	-11.5	4.9	-51.2	11.4	-19.6	8.4	-28.2	27.9
FRA	Female	-9.6	4.9	-40.7	13.0	-16.7	9.4	-5.5	25.2
FRA	Male	-13.5	6.0	-58.3	11.9	-23.8	10.1	-44.9	30.8
FRA	Low SES	-1.6	7.8	-41.1	12.6	-34.2	14.4	-43.7	26.4
GBR	All	-2.5	3.1	2.2	4.7	-0.8	7.8	-17.6	9.9
GBR	Female	-5.6	3.5	2.2	5.2	4.2	8.1	-22.2	12.6
GBR	Male	1.0	4.6	2.2	6.4	-6.5	10.9	-14.3	13.7
GBR	Low SES	-2.3	4.7	1.0	7.8	2.9	10.9	-0.1	20.0
GRC	All	-18.3	3.6	-24.9	5.9	-5.5	7.1	1.3	9.9
GRC	Female	-13.7	3.7	-23.4	6.5	-4.4	7.2	1.9	12.0
GRC	Male	-23.3	4.4	-27.2	6.9	-6.9	8.4	4.6	11.5
GRC	Low SES	-20.4	5.4	-25.9	6.6	-2.5	10.1	7.7	10.5
HUN	All	-12.5	4.0	-70.4	6.8	-0.7	9.0	20.9	18.3
HUN	Female	-11.3	4.0	-74.3	8.9	-3.6	9.0	24.6	23.5
HUN	Male	-13.9	4.8	-67.3	7.9	3.0	11.2	17.2	20.7
HUN	Low SES	-16.7	4.8	-65.7	8.2	6.3	13.4	17.0	21.6
IRL	All	-1.4	2.8	-6.6	3.8	-4.8	5.9	-7.0	7.9
IRL	Female	-2.8	3.2	-5.9	4.0	4.5	8.2	-1.7	9.5
IRL	Male	0.1	4.1	-7.0	5.1	-15.6	7.7	-14.4	9.6
IRL	Low SES	13.6	3.6	15.2	4.2	-5.8	9.0	-15.3	11.3
ISL	All	-10.1	1.7	-12.9	2.1	-10.6	4.8	1.4	7.5
ISL	Female	-13.9	2.4	-9.8	2.9	-4.1	6.6	8.0	10.4
ISL	Male	-6.2	2.7	-16.0	3.8	-18.6	6.3	-6.2	9.6
ISL	Low SES	5.0	7.4	13.7	7.0	-30.8	12.9	-10.0	16.6
ISR	All	-19.8	4.2	-15.6	6.2	-10.6	10.5	-19.8	12.8
ISR	Female	-14.5	3.8	-13.7	5.8	-11.3	9.8	-19.5	13.5
ISR	Male	-25.8	6.2	-18.0	8.8	-13.1	16.4	-25.6	18.1
ISR	Low SES	-26.1	7.0	-30.7	9.9	-15.2	16.0	-17.0	16.8
ITA	All	-9.9	3.3	-37.8	7.6	-2.1	8.1	34.4	14.6
ITA	Female	-7.3	3.6	-30.9	9.7	-6.6	8.6	29.7	16.8
ITA	Male	-12.2	3.9	-41.6	8.2	2.3	9.3	35.7	16.1
ITA	Low SES	-7.4	4.0	-30.3	9.8	-8.2	11.1	37.4	24.7
KOR	All	-6.6	5.7	-9.8	16.0	8.6	9.8	-15.3	22.8
KOR	Female	0.4	5.5	-7.9	18.7	-0.2	12.9	-2.4	24.9
KOR	Male	-12.8	7.9	-11.7	16.4	16.1	12.0	-22.3	27.4
KOR	Low SES	-5.8	7.1	-23.6	14.2	9.0	16.4	-18.2	25.1
LTU	All	-14.1	2.5	-34.7	3.5	-7.0	4.7	-13.4	6.8
LTU	Female	-12.4	2.7	-32.7	3.9	-8.3	6.3	-10.8	8.5
LTU	Male	-15.9	3.1	-35.8	4.3	-4.8	5.5	-16.7	8.5
LTU	Low SES	-8.4	3.7	-29.5	4.0	-3.9	7.5	-21.1	8.3
LVA	All	-11.5	2.7	-30.6	3.5	-14.9	5.5	-16.1	6.7

Funded by
the European Union

LVA	Female	-7.6	3.2	-24.4	4.0	-16.5	6.2	-22.2	7.7
LVA	Male	-15.6	3.1	-36.5	4.4	-13.3	7.3	-11.2	9.7
LVA	Low SES	-11.1	4.0	-34.0	4.5	-9.5	8.5	-7.7	9.2
MEX	All	-21.4	2.4	-50.5	2.7	-9.8	5.1	4.8	11.7
MEX	Female	-18.4	2.6	-44.5	3.3	-10.0	5.8	3.9	11.1
MEX	Male	-24.6	2.7	-56.5	3.0	-9.6	5.6	5.2	14.7
MEX	Low SES	-21.3	2.7	-51.4	2.8	-9.1	5.7	-0.1	8.9
NLD	All	-9.8	6.8	-58.9	26.0	-4.0	13.1	87.3	38.4
NLD	Female	-6.5	6.8	-47.6	25.4	-5.4	13.2	71.0	40.7
NLD	Male	-12.9	7.5	-69.0	29.2	-2.8	14.6	103.9	38.3
NLD	Low SES	-10.5	9.8	-56.0	36.5	17.5	16.8	107.7	72.7
NZL	All	-14.4	2.5	-28.7	4.8	-2.2	5.4	35.1	9.8
NZL	Female	-15.8	3.2	-23.6	5.6	1.5	6.3	22.5	12.1
NZL	Male	-12.6	3.2	-33.4	6.8	-5.0	7.6	49.6	15.3
NZL	Low SES	-7.1	5.8	-15.1	7.6	-4.2	10.3	33.5	16.8
POL	All	-10.4	2.7	-21.2	2.7	-8.4	7.2	-27.8	13.3
POL	Female	-8.6	3.0	-14.5	3.3	-5.4	6.9	-36.0	15.2
POL	Male	-12.3	3.7	-27.7	3.6	-12.1	10.3	-21.3	17.1
POL	Low SES	-7.9	3.8	-14.8	3.8	-2.3	11.3	-31.8	15.4
PRT	All	-12.0	3.4	-41.6	8.4	-2.5	7.2	39.8	28.1
PRT	Female	-8.9	3.4	-37.2	9.3	-4.7	6.8	53.8	26.4
PRT	Male	-15.4	4.4	-45.2	9.0	0.2	9.1	26.9	33.1
PRT	Low SES	-9.9	5.8	-37.7	9.9	-5.2	11.7	42.6	29.4
SVK	All	-18.2	3.8	-55.2	4.3	-11.5	7.4	0.2	9.6
SVK	Female	-14.9	3.9	-53.7	4.6	-15.3	7.5	1.5	10.3
SVK	Male	-22.1	5.2	-57.0	6.1	-7.3	10.6	-0.8	13.4
SVK	Low SES	-15.8	6.5	-51.2	7.1	-25.3	13.6	-21.3	15.3
SVN	All	-12.1	1.4	-31.5	4.8	-4.4	3.0	22.1	9.0
SVN	Female	-7.3	1.8	-22.6	8.8	-3.8	4.0	13.3	14.4
SVN	Male	-17.1	2.1	-39.1	7.6	-5.7	4.8	29.5	14.5
SVN	Low SES	-12.0	3.0	-28.6	8.7	5.4	7.6	25.4	21.4
USA	All	2.8	3.3	-3.4	5.4	-2.7	7.9	-8.4	13.3
USA	Female	2.9	3.6	-4.0	5.6	-6.5	7.9	-5.0	12.5
USA	Male	2.6	3.8	-2.9	6.5	1.1	10.1	-11.8	18.0
USA	Low SES	9.3	4.4	10.9	7.7	-12.3	12.8	-36.0	20.3

Table A. 3. Mean differences in science score across levels of urbanity (ref. city) for pooled 2009–2018 PISA rounds and the change in 2022.

		Pooled 2009-2018 rounds				Interaction effect			
Country	Population	Town	Town (SE)	Rural area	Rural area (SE)	2022* town	2022* town (SE)	2022* rural	2022* rural (SE)
AUS	All	-16.2	2.0	-21.0	4.0	-4.0	4.7	-21.7	11.3
AUS	Female	-13.9	2.2	-11.8	4.3	-0.1	5.3	-29.4	11.6
AUS	Male	-18.6	2.3	-30.5	5.1	-8.1	5.9	-13.7	15.6
AUS	Low SES	-8.8	2.7	-11.1	5.9	-0.1	7.5	-28.1	14.7
AUT	All	-2.7	3.2	-13.4	7.6	-2.1	5.5	7.0	18.7
AUT	Female	-2.5	3.3	-6.2	7.8	1.7	6.5	-1.0	20.6
AUT	Male	-3.3	5.2	-18.3	9.8	-5.7	7.7	12.2	22.1
AUT	Low SES	8.5	4.7	1.8	8.5	-7.5	9.4	-0.8	20.5
BEL	All	13.3	3.7	8.8	9.9	-14.5	7.2	-33.9	34.2
BEL	Female	17.7	4.0	21.2	7.4	-17.8	8.3	-28.7	25.6
BEL	Male	8.5	4.4	-5.1	16.4	-11.0	8.9	-31.4	42.7
BEL	Low SES	17.0	4.3	-4.9	22.4	-21.8	8.8	-21.5	42.7
CAN	All	-7.8	1.7	-13.0	2.8	-10.5	4.2	-8.8	8.9
CAN	Female	-5.3	2.0	-9.1	3.4	-7.6	5.1	-10.1	11.0
CAN	Male	-10.3	2.1	-16.8	3.4	-13.5	5.1	-7.7	9.4
CAN	Low SES	-0.5	2.9	-3.8	4.2	-2.5	5.2	-12.6	9.1
CHE	All	-16.4	4.4	-26.8	5.0	-4.1	8.7	-3.5	11.4
CHE	Female	-16.4	4.7	-26.0	5.5	-4.9	9.8	-7.5	13.1
CHE	Male	-16.4	5.2	-27.4	5.8	-2.9	9.4	0.8	13.5
CHE	Low SES	-4.7	6.4	-8.1	7.2	-9.6	11.9	-31.2	13.3
CHL	All	-8.5	3.0	-37.8	6.2	1.9	5.9	-8.5	17.8
CHL	Female	-4.6	3.5	-33.3	8.0	-2.8	6.8	18.0	24.3
CHL	Male	-12.5	3.6	-41.0	7.5	6.6	7.0	-21.7	24.6
CHL	Low SES	-10.4	3.2	-45.0	7.6	3.0	7.6	-16.7	13.6
COL	All	-14.1	3.5	-26.9	4.7	-14.5	6.3	-4.9	9.3
COL	Female	-12.1	3.5	-18.0	5.1	-12.7	6.8	-9.5	10.0
COL	Male	-16.4	4.1	-36.4	5.7	-16.2	7.3	0.2	10.3
COL	Low SES	-11.3	3.7	-27.1	5.5	-9.4	7.5	0.0	9.9
CZE	All	-14.2	3.6	-29.8	6.0	-6.5	7.6	-15.9	8.6
CZE	Female	-11.0	3.8	-25.0	6.4	-3.2	8.6	-22.1	11.7
CZE	Male	-17.1	5.0	-33.5	7.5	-10.7	8.6	-12.8	9.7
CZE	Low SES	-13.9	5.8	-23.7	8.3	-1.4	11.5	-14.8	13.1
DEU	All	4.3	5.0	-11.9	11.7	0.6	9.2	-10.3	16.8
DEU	Female	7.8	5.5	0.5	12.8	-3.4	10.6	-29.2	17.6
DEU	Male	0.8	5.4	-23.7	12.3	4.8	10.1	8.1	20.9
DEU	Low SES	13.6	6.5	-5.2	15.0	-3.2	12.7	4.9	20.8
DNK	All	-2.6	2.8	-8.5	3.4	-13.8	5.6	-15.3	8.1
DNK	Female	-5.4	3.7	-8.6	4.2	-9.4	7.2	-11.1	10.1
DNK	Male	0.2	3.2	-8.8	4.1	-18.2	7.6	-19.2	9.2
DNK	Low SES	1.1	4.2	-2.5	6.0	-10.8	11.9	-14.5	14.4
ESP	All	-6.1	1.8	-4.7	3.1	1.0	3.8	5.4	6.8
ESP	Female	-3.1	1.8	5.2	4.0	1.5	4.3	-0.6	9.0
ESP	Male	-9.1	2.2	-15.1	4.0	0.5	4.3	11.7	6.7
ESP	Low SES	-2.7	2.7	-0.7	3.5	-5.3	6.3	-1.2	8.5

Funded by
the European Union

EST	All	-9.2	2.7	-10.1	3.4	-0.5	5.0	-0.7	6.7
EST	Female	-4.4	2.8	-5.5	3.7	2.5	6.1	3.4	8.4
EST	Male	-14.3	3.4	-14.9	4.0	-3.3	5.7	-4.8	8.4
EST	Low SES	-0.8	3.9	2.8	5.0	-10.1	8.0	-24.3	9.9
FIN	All	-5.2	2.3	-0.6	3.8	-9.4	5.0	-18.4	8.7
FIN	Female	-3.6	2.4	4.2	4.3	-7.1	4.8	-17.2	9.9
FIN	Male	-6.7	3.0	-4.9	4.8	-12.0	6.8	-20.0	12.8
FIN	Low SES	0.9	4.5	8.8	6.2	-6.1	7.0	-6.1	12.6
FRA	All	-5.9	4.5	-39.1	9.2	-20.3	7.7	-35.8	27.4
FRA	Female	-5.0	4.5	-30.8	10.7	-16.5	8.0	-7.7	22.4
FRA	Male	-6.9	5.6	-44.9	9.9	-25.1	9.4	-52.6	29.6
FRA	Low SES	4.7	7.0	-27.4	10.3	-33.3	14.1	-46.2	24.9
GBR	All	3.3	3.3	10.7	5.1	-7.5	7.6	-27.7	9.8
GBR	Female	0.8	3.8	11.8	5.5	1.9	8.2	-33.3	11.8
GBR	Male	6.4	4.7	10.1	6.7	-18.0	10.5	-24.1	12.4
GBR	Low SES	9.0	4.8	13.7	9.0	-13.9	9.6	-32.1	24.0
GRC	All	-13.1	3.6	-23.1	5.4	-8.7	6.7	6.4	8.0
GRC	Female	-9.5	3.6	-23.2	6.1	-8.7	7.2	5.2	8.9
GRC	Male	-16.9	4.0	-23.3	6.1	-8.6	7.8	9.7	10.4
GRC	Low SES	-14.7	4.9	-22.3	6.5	-6.3	9.1	10.8	10.6
HUN	All	-11.2	4.0	-73.0	7.2	-3.5	8.8	29.0	18.7
HUN	Female	-9.5	4.1	-77.2	9.7	-7.1	8.8	38.3	23.2
HUN	Male	-12.9	4.6	-70.5	7.7	0.2	10.7	21.4	20.3
HUN	Low SES	-15.7	4.5	-65.7	7.8	-1.2	12.2	22.9	21.1
IRL	All	2.5	2.5	-1.3	3.6	-10.2	6.0	-14.8	8.5
IRL	Female	2.7	2.9	0.2	4.0	-0.9	7.8	-7.7	10.3
IRL	Male	2.4	3.6	-2.5	4.8	-21.2	8.1	-23.8	10.3
IRL	Low SES	17.9	4.1	22.5	4.8	-8.8	10.9	-18.3	12.9
ISL	All	-11.4	1.6	-8.4	2.4	-10.0	4.1	3.6	6.5
ISL	Female	-14.5	2.3	-6.5	3.3	-4.6	5.4	12.9	9.4
ISL	Male	-8.2	2.7	-10.4	4.1	-15.7	6.4	-5.7	10.2
ISL	Low SES	3.6	6.5	15.1	6.5	-18.7	12.7	-2.4	16.3
ISR	All	-12.5	4.0	-4.2	6.2	-8.2	10.3	-25.0	11.1
ISR	Female	-7.1	3.7	-1.0	5.5	-10.1	8.2	-17.9	10.5
ISR	Male	-18.6	6.3	-7.8	9.0	-8.4	17.5	-33.7	17.3
ISR	Low SES	-17.4	6.6	-15.1	8.6	-6.2	12.9	-15.1	13.4
ITA	All	-7.9	3.4	-24.8	7.7	-3.7	9.3	31.7	23.8
ITA	Female	-5.6	3.8	-17.9	9.6	-6.9	9.7	30.4	30.1
ITA	Male	-9.7	3.9	-29.4	7.7	-0.9	10.5	30.9	21.3
ITA	Low SES	-4.7	4.2	-17.6	10.7	-9.5	12.3	20.7	31.8
KOR	All	-6.3	5.6	-7.7	14.5	-0.4	10.9	-42.0	16.6
KOR	Female	0.0	5.6	-6.0	19.4	-5.9	12.5	-34.0	26.2
KOR	Male	-11.9	7.7	-9.6	12.2	4.1	12.7	-46.4	17.8
KOR	Low SES	-3.0	6.9	-19.1	10.9	1.2	14.5	-68.3	23.3
LTU	All	-12.4	2.8	-26.3	3.5	-9.2	5.0	-19.7	7.5
LTU	Female	-11.0	3.0	-25.9	4.0	-10.3	6.4	-11.8	9.5
LTU	Male	-14.0	3.3	-26.3	4.3	-7.6	5.7	-28.8	8.3
LTU	Low SES	-7.4	4.0	-20.7	4.5	-1.0	8.2	-22.6	10.1
LVA	All	-7.6	2.7	-17.7	3.9	-13.8	4.6	-23.0	6.5
LVA	Female	-4.1	3.3	-10.7	4.4	-14.3	6.0	-28.4	7.9

LVA	Male	-11.4	3.1	-24.3	4.9	-13.3	6.0	-18.5	9.6
LVA	Low SES	-7.5	3.9	-18.5	4.5	-9.9	8.5	-15.1	9.5
MEX	All	-17.4	2.0	-39.8	2.2	-11.0	4.7	-3.9	10.8
MEX	Female	-14.9	2.3	-33.5	2.8	-10.6	5.5	-1.9	9.8
MEX	Male	-19.9	2.3	-46.1	2.7	-11.5	5.0	-7.1	13.5
MEX	Low SES	-15.8	2.2	-39.6	2.3	-11.5	5.4	-6.3	8.2
NLD	All	-8.5	6.9	-47.0	25.1	-1.4	13.2	79.7	38.5
NLD	Female	-4.7	6.9	-33.7	22.1	-3.3	13.1	61.7	37.2
NLD	Male	-12.1	7.5	-58.2	30.5	0.2	14.4	97.2	42.3
NLD	Low SES	-8.5	10.0	-40.3	28.4	20.7	17.0	96.7	62.2
NZL	All	-9.4	2.6	-21.8	4.5	-5.0	5.2	31.6	10.0
NZL	Female	-11.5	3.3	-13.5	4.6	-0.4	5.9	22.2	14.2
NZL	Male	-7.2	3.3	-29.8	6.9	-9.8	7.3	40.9	13.8
NZL	Low SES	-3.5	6.1	-5.3	7.2	-3.9	10.6	21.8	22.3
POL	All	-9.8	2.4	-16.7	2.5	-5.3	6.6	-21.7	13.7
POL	Female	-8.6	3.1	-10.8	3.3	-2.1	6.8	-17.0	16.7
POL	Male	-11.0	3.3	-22.6	3.3	-8.6	9.5	-25.8	16.0
POL	Low SES	-4.5	4.0	-8.0	3.9	-3.5	9.9	-20.2	16.6
PRT	All	-9.1	3.0	-36.3	7.4	-3.3	6.2	38.2	24.3
PRT	Female	-5.9	3.1	-29.6	9.0	-3.5	6.5	46.9	27.6
PRT	Male	-12.6	3.9	-42.2	7.3	-2.9	7.5	30.8	24.3
PRT	Low SES	-4.8	5.5	-30.1	8.9	-7.6	11.4	45.0	26.9
SVK	All	-13.0	3.9	-46.3	4.4	-17.8	7.7	-5.9	10.2
SVK	Female	-10.2	4.0	-43.7	5.0	-22.1	7.5	-5.1	9.7
SVK	Male	-16.1	5.1	-48.8	6.3	-12.8	10.6	-5.4	13.9
SVK	Low SES	-6.3	5.6	-39.9	6.2	-30.7	13.1	-21.5	13.6
SVN	All	-9.8	1.7	-27.2	5.2	-12.3	3.1	15.4	6.6
SVN	Female	-6.3	2.4	-21.5	8.3	-10.1	4.6	7.0	13.7
SVN	Male	-13.6	2.3	-32.1	7.4	-14.0	4.1	23.8	10.8
SVN	Low SES	-12.5	3.1	-27.9	8.7	-1.9	5.7	21.6	18.5
USA	All	9.2	3.4	6.7	5.5	-3.8	8.1	-8.9	11.4
USA	Female	9.8	3.7	6.1	5.6	-6.4	8.0	-7.9	13.3
USA	Male	8.8	3.9	7.3	6.5	-1.3	10.4	-9.7	16.0
USA	Low SES	15.5	4.2	19.9	6.9	-12.9	12.1	-8.9	23.1