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DISCUSSION PAPER SERIES

IZA DP No. 14298

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ABSTRACT

Learning Loss and Educational Inequalities in Europe: Mapping the Potential Consequences of the COVID-19 Crisis[1]

It is widely discussed that the pandemic has impacted on educational inequalities across the world. However, in contrast to data on health or unemployment, data on education outcomes are not timely. Hence, we have extremely limited knowledge about the actual impact of the pandemic on learning outcomes at the national and the cross-national level. As it might take years to get new comparative evidence on the actual extent of the problem, this paper uses the latest large scale international student assessment data from before the pandemic, the Trends in International Mathematics and Science Study (TIMSS) 2019 and applies simple descriptive analysis, regressions and logical deductions to map potential consequences of the Covid-19 crisis across Europe. We obtain the relative trajectories of children's learning loss and its unequal distribution from information on home and school resources, the importance of these resources for learning outcomes and countries' school closure duration policies and compare Covid-19 related risk of learning loss between European countries. Results based on 4th graders' school achievements indicate that throughout Europe educational inequalities between and within countries are likely to increase substantially. Some European countries are highly likely to face already an education crisis.

JEL Classification: I24

Keywords: educational inequalities, COVID-19, Europe, learning loss

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1 Introduction

Children have the lowest risk of falling severely ill if exposed to the Covid-19 virus. However, they have suffered in several ways as a result of the pandemic-related physical school closures which led to around 58 million primary and secondary children being deprived of face-to-face learning for many weeks in the EU-27 countries only. Students' mental well-being, their access to nutrition, social life, their risk to become a victim of domestic violence have all been affected. In addition, they are likely to have suffered a considerable learning loss. Our paper is concerned with this latter point focusing on primary school children in European countries.

Timely information on the actual educational consequences of the crisis are scarce even at the national level, and will remain most likely unavailable for a long time cross-nationally[2]. Given the serious risks the Covid-19 crisis poses on children's learning outcomes and their future life time chances, we cannot afford to wait for the optimal data to arrive but instead need to make most out of the available data sources to help inform policy makers about a problem, that compared to timely measurable issues like the economy, health and employment might have been overlooked at the policy agenda. We therefore exploit the most recent pre-Covid International Large Scale Assessment (ILSA), the Trends in International Mathematics and Science Study (TIMSS) 2019, to examine possible and relative trajectories of countries in terms of both education outcomes and inequalities. Since research shows that younger pupils are losing most out during distances learning (Fuchs-Schündeln et al., 2020), the study is focusing on 4th grade children in primary schools that are around 10 years of age. These children will still have many years in school, so that the right policy design can support them to overcome possible learning losses experienced during the pandemic.

After reviewing educational research important for evaluating the impact of school closures on learning outcomes, we investigate in four steps the importance of the crisis on educational outcomes. First, we map countries on the share of disadvantaged children who lack important home and school resources for progressing in learning from their home. This analysis can help us to understand how educational inequalities will increase between countries. Second, we investigate how important these home resources were for learning progress before the pandemic. Assuming that during the pandemic home resources and parental background are even more important than before, we outline those countries in which children are likely to fall more behind. This analysis therefore examines possible trajectories of educational inequalities within countries. In a third step, we combine these both measures. Clearly, countries which show both, probable trajectories of lower average achievement and higher educational inequalities compared with other countries are those, which are most likely to leave a substantial share of pupils behind. We also show, that some countries with higher risk of learning loss among pupils and decreasing equity tended to close schools for longer. In a fourth step, we provide some insights on how to tackle low achievement. For some countries, we highlight that policy makers would not necessarily just need to support low performing students, but could already improve educational outcomes overall by supporting rural schools and those schools with on average low achievement.

[2] Among the international large scale assesment studies, the PIRLS 2021 study from IEA is presently in the data collection phase with still unsure outcomes due to the Covid situation. The data is expected to become available in November 2022. Data collection for the PISA 2021 study has however been postponed to 2022. The two single country studies available so far and exploiting student achievement data before and during the pandemic come from the Netherlands and Belgium – see Section 2.

The value added of the present study is therefore three-fold. First, to the best of our knowledge this study is the first one that confronts pre-Covid student assessment data with insights taken from Covid-19 studies to better understand the possible implications of the crisis across several European countries. Second, it is the first to map countries in terms of risks of low educational outcomes and equality due to the Covid-19 crisis, thereby highlighting in which countries children are most likely to be left behind. Third, we provide some insights on how policy makers could support students, at the individual, area or school level.

The rest of the paper is organized as follows. Section 2 reviews existing literature discussing both, the long-standing research on educational inequalities and recent COVID-19 studies in the field. Section 3 introduces our data and methods. Section 4 discusses the expected relative size of learning loss in the various countries and links this to pre-Covid country achievements. Section 5 maps socio-economic inequalities in education within the individual countries. It presents pre-Covid inequalities taking also the children's home resources into account and identifies countries with the greatest risk to face increasing inequalities. Section 6 combines results of the previous two sections, showing how countries compare on both dimensions together, risk of decreasing average achievement and equality of learning outcomes. Section 7 offers some decompositions of the inequalities identified, to better understand the possible sources of the variations and to support policy making in designing their recovery plans for education. Section 8 concludes and discusses some policy implications.

2 Mechanisms increasing learning loss and educational inequalities during physical school closure

From the early days of this pandemic, experts have been concerned that enforced distance learning would lead to massive learning losses in the affected student populations. Moreover, it was also noted that this learning loss will be uneven, leading to a significant increase in the pre-existing socio-economic gaps in education (Blasko & Schnepf, 2020; Blundell et al., 2020; Di Pietro et al., 2020; Hanuschek & Woessmann, 2020).

Research comparing the knowledge level of students before and after summer breaks often find a significant reduction in students' achievement – particularly so in mathematics (for the USA: Cooper et al., 1996; Downey et al., 2004; for Europe: Paechter et al., 2015; Shinwell & Defeyter, 2017), and it is argued that beside stagnation, an actual loss of knowledge is also taking place when education is discontinued. Studies on school-closures due to teacher-strikes lead to similar conclusions. (Belot & Webbink, 2010 and Baker, 2011).

However, school closures do not only decrease overall levels of students' knowledge but lead to increasing social gaps in education outcomes. Studies in the US consistently find the summer learning loss in mathematics but especially in reading skills to be highly heterogeneous by social background (Cooper et al., 1996; Downey et al., 2004). These summer-break effects in primary school continue to widen the social gap between high and low socio-economic background students in grade 9 and can even influence high school achievements (Alexander et al., 2007). School learning reduces socio-economic inequality in achievement because instruction time in schools tends to be more beneficial for children from families with lower income and socio-economic background than for the more socially advantaged ones (Lavy 2015, Burger 2016).

Literature measuring the actual extent of learning loss due to the Covid-19 pandemic is still scarce, since these studies rely on availability of achievement measures before and after the crisis. One study (Engzell et al., 2020) builds on exceptionally rich administrative data from the Netherlands. They find that irrespective of the subject (math, spelling or reading) young students aged 7 to 11 made only very limited learning progress during the eight weeks of distance teaching in spring 2020. This represents a learning loss of around 3 percentage points, or 0.08 standard deviations compared to similar grade students in the previous years. The loss was significantly bigger among students with less educated parents, inevitably increasing the socio-economic achievement gap. According to another study, the 2020 cohort of 4th grade students in selected Belgian Flemish schools achieved an average maths test score of 0.19 standard deviations and an average Dutch test score of 0.29 deviations below the results of the preceding cohorts (Maldonado & Witte, 2020). Inequalities both within and between schools increased and the size of learning loss was positively correlated with the share of low socio-economic background students in the school.

In contrast to school closures due to summer-vacation or teacher strikes, in distance learning times schools and teachers continue to help student progress in their learning and hence can somewhat compensate for home-related disadvantages. Their means are however limited. To minimise learning losses, children have to increasingly rely on physical and cultural assets available at home not only to spend their free time (such as in normal school breaks) but also to be able to follow distance education. As these resources are unevenly distributed across families, it is inevitable that not all children will equally benefit from distance learning leading to heterogeneous learning loss. Moreover, the more children in a country lack home resources to reduce learning loss, the bigger the overall learning loss in the country will be. Our study therefore focuses on both of these aspects: size and heterogeneity of the expected learning loss.

Home resources are widely discussed as key factors in driving social inequalities in school achievements also in 'normal' times. A massive body of research has by now successfully identified additional learning gains – both related to and beyond the influence of parental education – associated with material circumstances and cultural home climate including availability of books (e.g. Brunello et al., 2016; Sikora et al., 2019); parental time investment, learning support and engagement in educational activities (Araújo & Costa, 2015; Macmillan & Tominey, 2019); having an adequate, healthy nutrition (e.g. Belot and James 2011; Florence et al., 2008) and – under certain conditions – ICT usage at home (Biagi & Loi, 2013; Luu & Freeman, 2011). While important predictors of school achievements in normal times, we argue that these resources gain special importance during physical school-closures and their lack can further intensify the learning loss caused by the pandemic.

The most evident and widely discussed instrument of distance learning is access to ICT tools and the internet. National studies during the pandemic show clear and notable social gradients in children's access to a computer (See e.g. Bol, 2020 in the Netherlands; Andrew et al., 2020 in the UK). Differences in access to broadband internet by household income and acrpss European countries are also apparent from pre-COVID data as discussed by DiPietro et al. (2020). Country studies further indicate that children in more educated families are also more likely to own a dedicated and quiet place for study, let it be a room or an own desk (Bol, 2020).

At the same time, the lack of access to school meals for children living in poverty during school closures raised serious concerns in many countries in Europe (Eurochild, 2020).

The quantity and quality of parental support provided during the pandemic is more difficult to assess as well as to compare across social groups and across countries. Long-standing literature shows that parents with lower income and in the lower societal strata provide less activities and support for their children (e.g. Strietholt et al 2019) and spend generally less time with them (Sayer et al., 2004). During COVID-19 times, however, when educational support to students was required during working hours and families had to cope with particular difficulties and work-life conflicts (Blasko, 2020), the situation might have changed. Covid-19 surveys in the UK (Cullinane & Montacute, 2020) and Ireland (O. Doyle, 2020) found no, or at most minor differences in the overall time parents spent on supporting their children either by income level or by parental education. A Dutch study on the other hand reported a notable gap with the more educated parents being more active (Bol, 2020) – a finding also supported by surveys on parental time use during the lockdowns e.g. in Italy (Boca et al., 2020) and in Hungary (Fodor et al., 2020). At the same time, both the Dutch and a UK survey find educated parents feeling more capable and more confident to help their kids with their schoolwork (Bol, 2020; Cullinane & Montacute, 2020). The availability of parents to help as well as their efficiency in doing so might also depend on their stress-level and mental wellbeing – it is however unclear how these were associated with education and income level during the crisis (Huebener et al., 2020; Salari et al., 2020; Shevlin et al., 2020). Finally, the higher learning time of children from higher SES families compared to their less advantageous peers during school closure days as found in several surveys (Andrew et al., 2020; Bol, 2020; Cullinane & Montacute, 2020) can also be considered as an indication of parental motivation and support benefitting again the higher status children. A German study (Grewenig et al., 2020) on the other hand found no parental education effect neither in the extent to which students reduced their learning time in the lockdowns, nor in the amount of time they spent on conducive and detrimental activities, or in the extent to which parents increased the time they spent with their children. All these factors were instead significantly correlated with students' previous achievements in school.

During summer breaks, differences in family circumstances constitute the main drivers of social inequalities in the learning experience. In times of distance teaching however between-school differences in quality and effectiveness of teaching also continue to play a role. Research now confirms that schools did not cope uniformly with the immense challenges of distance teaching. In addition, their adaptability was correlated with the social composition of their student bodies. In the UK, teachers in higher status neighbourhood schools, and particularly in private schools felt more confident to broadcast a lesson to their class and were indeed more active in reaching out to their students during the pandemic (Cullinane & Montacute, 2020). Large differences in the number and variety of online resources offered by the school were also found by another UK survey. The latter discovered that availability of online resources was strongly related to the school's status (private or public) as well as to the social composition of the (public) schools (Andrew et al., 2020). Notably, poorest parents were the least likely to report that their child's school offers interactive resources – such as private tutoring, text chatting or even online lessons. Similar disparities were also found in Ireland (Doyle, 2020) but not in the Netherlands (Bol, 2020).

Up to now, we have little comparative evidence on how the different national education systems and the affected families in Europe dealt with the distance learning situation. The few available studies point at notable cross-country variations, that will most likely affect the amount of learning loss. A survey from April 2020 shows that a much higher proportion of primary school children were offered on-line classes in Italy (65%) than in France (20%) (Champeaux et al., 2020). Looking at the distance learning experiences of students aged 10 to 18 in 11 European countries[3], a JRC study (Vuorikari et al., 2020) finds that the proportion of students that had some form of daily interaction with their school during the first lockdowns varied between 34% in Germany and 78% in Norway. Big discrepancies were also found in the level of parental involvement: less than one third of parents in Slovenia and Norway said that they engaged in children's educational activities at their own initiative as opposed to three quarter in Portugal and Romania.

While existing literature tends to look at different home resources and school factors in isolation and typically offers single-country cases studies, this study examines these indicators on learning progress and inequalities together in a European comparative perspective.

3 Data and methodology

This study exploits the international large scale assessment study, TIMSS 2019, which is organised by the International Association for the Evaluation of Education. The sample design of TIMSS is organised in two stages across countries participating: first a representative sample of schools is drawn, second 4th grade primary school pupils within sampled schools are randomly selected. On average across the 22 European countries analysed here[4], around 4,400 students were sampled per country showing the considerable effort and budget invested into this survey.

While the competitor survey Programme for International Student Assessment (PISA) organised by the OECD aims to measure functional literacy in the sense of how students can apply their skills to function in their societies, TIMSS measures achievement by focusing on curricula based learning outcomes. TIMSS looks at maths and science learning achievement. Since during distance learning schools tended not to teach all subjects, we only focus on maths achievement, a subject quite likely to have been covered in learning activities during physical school closure.

Responding students receive a battery of maths questions. Their answers are summarized in an estimate of a pupil's 'proficiency' for maths. For doing so, an item response (IR) model is applied which considers items' degree of difficulty, their power to discriminate between individuals with high and low ability and the possibility of guessing. Across all participating

[3] Participating countries were Austria, France, Germany, Ireland, Italy, Portugal, Romania, Slovenia and Spain, Switzerland and Norway.

[4] Countries included in the analyses are: Austria (AT), Bulgaria (BG), Croatia (CR), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Finland (FI), France (FR), Germany (DE), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Malta (MT), Norway (NO), Poland (PL), Portugal (PT), Slovak Republic (SK), Spain (ES), Sweden (SE) and Belgium-Flemish (BE (Fl)). We excluded the Netherlands, England and Northern Ireland due to lack of information on important characteristics of the students (like parental education and parental book reading). For simplicity, in the paper we refer to "countries" although in the case of Belgium the study refers to the Flemish education system only.

students and countries, the constructed mean maths achievement score is around 500 with a standard deviation of 100.

TIMSS data does not only cover science and maths achievement of students, but also background information on parents, teachers and schools. As a consequence, with TIMSS 2019 data it is possible to examine in detail educational achievement and pupils' specific learning environment at home and school just before the pandemic.

For the analysis conducted, missing values are generally small for all variables with the exception of parental education. For Bulgaria, Croatia and the Slovak Republic missing values are below 5%, however in Germany, Denmark and Norway non-response exceeds 35%. In some cases, a high share of missing values occurs also for other variables, therefore results should be handled with special care for Germany, Denmark, Norway but also in Czechia, Lithuania, Malta and Norway. Students with missing parental education data are considered in the bivariate statistics if parental background is not examined. They are excluded in the regression design. (For missing values see the Appendix, Table A1.)

In order to examine the association of home resources and parental background with achievement as dependent variable, we conduct OLS regressions taking the design features of the survey (plausible values and weighting) into account.

4 Trajectories of learning loss across European countries

The longer the schools are physically closed and the more time students spend in distance learning, the higher the expected learning loss (Engzell et.al 2020). Further, we can also expect countries which invested more into digital education thereby being well equipped with ICT tools and internet connection to better respond to the crisis. These countries are also more likely to have invested more in teacher training on digital skills and therefore provide higher quality distance learning thus minimise learning losses during the pandemic. Figure 1 links these two pieces of information for all the 27 EU member states plus the UK and Norway.

While acknowledging the diversity of national and even regional pandemic responses related to education, in that they go '…far beyond the categorisation of keeping … primary schools 'opened' … or 'closed'…' (Blum & Dobrotić, 2020, p. 2), for data availability reasons we rely on UNESCO[5] data to calculate the length of periods when schools were closed in the entire country due to Covid-19[6]. We assume that in times of partial school closures primary schools were still open as this indeed seemed to be the common practice at least in the second wave of the pandemic. It is of course possible that primary schools were also affected by regional or other types of partial school closures, or that students in individual schools or even classes had to be quarantined for some additional period of time. The figures we use can therefore be considered as lower estimates of the time children spent without in situ teaching due to the Covid-19 pandemic up to end of February 2021 – that is during the first year of the crisis. Unfortunately,

[5] Own compilation based on UNESCO information from here: https://en.unesco.org/covid19/educationresponse. We calculate the number of weeks the schools were closed due to the pandemic between February 2020 and 28 February 2021.
[6] I.e. 'partial school closures' are not counted.

they are also optimistic estimates, as with the third wave of the pandemic developing in the early months of 2021, it is already clear that the periods are getting longer which could change the displayed country pattern over time.

To assess the countries' technical readiness for distance teaching, on the x-axis of Figure 1 we show the proportion of primary school children who study in a school that is considered to be at most partially equipped with ICT tools and good-quality internet connection, according to a survey carried out among school headmasters in 2017/18. The indicator is based on a number of measures describing the type and quality of internet access available in the school as well as the number and functionality of ICT equipment[7].

Figure 1 about here

Figure 1 identifies the Northern European countries as those in the best situation to deal with physical school closure, since they feature only a short period of school closure (y-axis) with high technical preparedness for online teaching. This analysis also confirms the assessment given by Engzell et. al (2020), in that the Netherlands represent (almost) a best case scenario, and their estimate of 0.08 standard deviation learning loss with a notable variation across students with different socio-economic backgrounds, can well be a lower estimate of the losses we can expect to see across Europe. Similarly, Belgium also appears as a country technologically well-prepared for distance teaching, which makes the estimates coming from the Flemish part of that country (Maldonado & Witte, 2020) also an optimistic one for many other European countries. However, children in countries at the top right corner of the graph, like those in Romania, Ireland, Poland, Bulgaria and also Austria were more likely to neither attend school nor having their schools being equipped for rolling out distance learning efficiently.

Figure 1 only provides a snapshot of two variables important for guiding learning progress during the pandemic. However, even in a school equipped with learning technology and digitally skilled teachers, students' home resources are key to learn when not attending school. Table 1 combines both, the distribution of individual and school learning resource based on TIMSS 2019, and compares them across countries. For individuals, the focus is on access to internet, access to a separate room to study, availability of reading material, being regularly hungry when arriving to school as well as a proxy of parental support. For schools, we measure the percentage of 4th graders that attend a school without an online learning management tool and those without access to digital resources. For each country, we provide the percentage of children that have no access to a given resource. To make the table easier to read, for each indicator we mark countries in the most disadvantaged third with dark grey, countries in a middle position (middle third of the distribution) light grey, while those that belong to the best-equipped third are left white.

[7] 2nd Survey of Schools: ICT in Education. Percentage of ISCED1 students that study in a school that is not highly digitally equipped and connected. 2017/18, FinalreportObjective1-BenchmarkprogressinICTinschools.pdf School-characteristics considered: availability of broadband speed internet; main means of internet access; indicators of connectedness; number of digital items provided by the school and whether or not the equipment is fully operational. A cluster analysis was applied to distinguish between 'highly' and 'partially' digitally equipped schools. For methodological details see also 2nd survey of schools - Publications Office of the EU (europa.eu)

To synthetize all this information, we rank countries on the basis of their relative positions among the TIMSS countries considering the availability of each of these resources. For each country, we calculate the mean value of the z-scores associated with each of the resources (Table 1, 8th column)[8]. Positive z-scores indicate that a country has a relatively high proportion of children lacking the resources, while negative values indicate that relatively few children live with such difficulties. While the use of the z-score is helpful in summarising complex information, it has its drawbacks. First, given that the TIMSS variable coverage is greater on students' than school variables, we only have two, rough indicators for proxying how well the schools were technically prepared for distance teaching and none about the teachers' capability. Second, countries' relative position depends on those 22 TIMSS countries covered. Third, the resources are not weighted by their actual importance for successful online learning which is unobservable. We therefore weight each variable equally for deriving the overall z-score, which includes an implicit value statement. Consequently, for evaluating countries specific positions, it is more useful to work with the colour shading and reflect in which third of the distribution countries rank (as shown by the lines within the table). Countries, with many pupils lacking the necessary resources for distance learning include Italy, Bulgaria, France, Croatia, Germany, Cyprus and the Czech Republic. As already suggested by Figure 1, countries that fare relatively well are Finland, Norway, Denmark and Sweden.

The last two columns of Table 1 display the contextual information: 4th graders' average maths achievement and countries' weeks of school closure. Countries with on average lower achieving children are more likely to face more obstacles to distance learning (defined by the overall z-score, correlation coefficent=-0.51). The association between the lack of resources on the country level and students' achievement is not surprising as higher school achievements are often found in more affluent countries, where there are also less students without access to basic resources. The implications during the Covid-19 crisis are however highly worrying as low access to resources will most probably intensify learning losses exactly in those countries that were already low-achieving before the crisis. As a consequence, between-county educational inequalities within Europe are very likely to grow.

This conclusion is further supported by comparing the overall z-score with school closure. While the two countries with the longest period of distance teaching so far (Ireland and Poland) are comparatively not poorly equipped with the resources necessary for online learning, still the overall correlation coefficient is a significant 0.31. Hence, countries with longer school closure up to February 2021 tend to be those which also have worse equipped students and schools. As a consequence, results on a variety of indicators suggest that Europe will face widening differences in educational outcomes between countries.

Table 1 about here

5 Trajectories of educational inequalities within European countries

Up to now, we examined likely increasing trajectories of between country inequalities in educational outcomes focusing on country differences and associations between students' and

[8] For the individual z-scores associated with each resource go to Appendix Table A1.

schools' lack of learning resources and school closure policies. This section does not deal with between country differences, but focuses on pandemic induced trajectories of inequalities within countries by examining the association of lack of resources with learning outcomes.

Research indicates that for all dimensions, previous inequalities within countries were likely to be exacerbated during the pandemic (Blundell et al 2020). To set the scene, therefore, it makes sense to focus first on pre-existing educational inequalities (Blasko and Schnepf 2020). Even though having its drawbacks, we define in line with existing research higher socio-economic background students as those who have at least one and lower socio-economic background as students who have no tertiary educated parents (Jerrim et al. 2019).

Figure 2 displays on the y-axis the learning gap in maths between TIMSS 4th graders with at least one parent having tertiary education compared to those with no parental tertiary education for European countries as measure of socio-economic background. For example, mean achievement of pupils with less educated parents is about 30 TIMSS points lower than of their peers with higher educated parents in Denmark which is equivalent to one year of learning gain in school. These differences are twice as large in Bulgaria, Hungary, France and Lithuania. The variation in the socio-economic achievement gap appears to be great given that in international comparison European countries are relatively homogenous in living standards and economic development.

The x-axis shows differences in internet access by parental education. The ratio of lack of internet access derives from dividing the share of disadvantaged pupils who lack access to internet by the share of advantaged pupils who lack access to internet. Countries with higher socio-economic achievement gaps tend to have also greater gaps in internet access between disadvantaged and advantaged children, even though the gap being significant only for 10 out of 22 countries: Bulgaria, Spain, Hungary, Latvia, Slovakia, Czechia, Belgium-Flanders, Portugal, Lithuania and Sweden. Access to important home resources is often related to the parents' educational level, although the strength of this association varies both across countries and across resources. Obviously, not all the children with low educated parents suffer from these additional disadvantages, while some others do so despite having more highly educated parents. In addition, as discussed above, parental education is only a proxy for socio-economic status. Parental resources, like books at home, are therefore also often used as additional measure of socio-economic status. Parents can have lower education but still a high paying job allowing them to invest into learning resources.

Figure 2 about here

In order to understand possible trajectories of inequalities, it is important to see how different countries managed to achieve good learning outcomes for disadvantaged children. Clearly, in those countries where children from lower socio-economic background and with less resources were already losing out before the pandemic, they are of much higher risk to perform even worse during the pandemic. This would lead then to even lower achievement for disadvantaged groups and consequently rising within-country educational inequalities.

To this end, we first employ OLS regression with maths achievement as dependent variable and parental education as explanatory variable (M1), adding the listed home resources in the

second step (M2). The regression on the pooled sample is conducted with the 22 European countries covered and employs country fixed effects. The first bar of Figure 3 shows the overall association between parental education and school achievements in 4th grade, while the second bar allows to calculate the score-loss associated with any combination of social disadvantages. (Main results also shown in Table A4 column 1.)

On average in the 22 countries in Europe, children with lower educated parents have a mean TIMSS maths score 48 points lower than that of their counterparts with higher educated parents. This pre-pandemic socio-economic gap, accounting for about 10% of average achievement, is substantial. The gap decreases by 9 point scores if we condition on access to home resources. The lack of any of the resources (or their possible characteristic as proxy measure for other aspects of socio-economic status than parental education), that are crucial for distance learning, decreases pupils' achievements already significantly before the crisis – adding up to a massive total learning deficit of 119 points. Clearly, this overall difference depicted in the graph is a theoretical construct. Only a very small proportion of 4th graders in Europe are lacking all the five resources – or even just four of them. In the overall European TIMSS sample, 37% of the pupils are equipped with all assets we are looking at, 39% are missing one of them, 19% are missing two, 4% three and 0.6 % four or more resources. Nevertheless, even this smallest percentage stands for around 20,000 4th graders in the 22 European countries examined.

Results show that children, who are the least likely to have access to the right learning resources for following online teaching properly, were already clearly and massively lagging behind in school before the pandemic started. Their lag will further increase, as these resources have an increased importance when schools are closed.[9] Results therefore confirm and strengthen those of the previous section: within Europe educational inequalities will increase.

Figure 3 about here

What are possible trajectories of educational inequalities within different European countries? For examining this question, we modelled the association of parental background and home resources for all countries examined. Results are provided in Table 2 (full regression results are reported in Table A4 in the Appendix). The regression coefficients indicate how much the average achievement of a child would decrease compared to a child having the resource. In general, lack of all of these resources but 'own study room' was significantly associated with

[9] Clearly, the association of home resources and parental background on learning outcomes during physical school closure and a time of economic crisis is likely to change, but both will impact on the possible trajectories of widening education inequalities in countries. The direction of change is difficult to predict for parental background. Covid-19 will have impacted on families with varying socio-economic background differently. Better educated parents were more probable to keep working from home, but struggling to balance child minding, supporting children with homework and work commitments. In contrast, parents with lower socio-economic backgrounds were more likely to go on working at their workplace or to lose their jobs. Even though not known up to know, on average we assume that children in households with parents who were working outside the home and faced great financial worries were worse off than those kids of parents who were around but had very limited time to support their children. Regarding home resources, it is quite obvious to assume, that their importance increases greatly during the pandemic, since they are the only learning resources available during lockdown. Since lower educated parents have on average less resources, this increase in home resources hits disadvantaged kids harder.

lower achievements in all countries. Students that had no access to internet and therefore had very little chance to follow online learning during the pandemic, were already lagging behind as much as between 16 and 44 TIMSS maths points compared to children with the resource before the pandemic in the European countries examined. It is important to remember, that this is conditional on family background and other resources.

To synthetize regression coefficients, Table 2 provides the 'overall home score' being equal to the sum of all regression coefficients and thereby displaying educational disadvantage of a child which would not have any resources and has lower educated parents compared to its peer advantaged in background and all resources. This reflects the worst case scenario, since as discussed above the share of children missing all resources is very small. The 'resources score' summarises only the regression coefficients of the resource variables. Countries are ordered by the overall home score. It is important to note, that we do not control for schools (school fixed effects) in the models. As such, school 'effects', like differences in value added by schools, are not isolated from the coefficients displayed.

Similar to Table 1, we group countries distinguishing between countries with strong (dark grey), medium (light grey) and weak (white) resource score. As can be seen, in countries, where the parental background association is bigger (higher overall home score), we typically also find the resource score to be large as well. In Lithuania, Ireland, Hungary, Bulgaria, Slovakia and also Germany, Finland and Malta the lack of home resources (with or without educated parents) is associated with particularly large learning disadvantages already before the crisis (correlation coefficient of 0.96).

Table 2 about here

6 Learning loss and educational inequalities combined

As discussed in Section 4, at the country level, a significant learning disadvantage due to lack of resources or parental background leads to bigger groups of underperforming students the more children live in such unfavourable circumstances. Table 1 displayed the share of students not having access to home and school resources. Table 2 of the previous Section instead shows the actual impact of the lack on learning outcomes. Figure 4 now merges both together, the overall measure proxying average resource lack and the overall measure capturing their importance for learning. The x-axis reports the mean z-score in lack (as reported in Table 1). The y-axis reports the overall home score (taken from Table 2)[10].

Figure 4 about here

Countries of lowest risk of learning loss are those in the left upper quadrant. In these countries, comparatively low number of students lack resources and these resources are also not so important for learning outcome (before the pandemic). Norway, Denmark and Austria fall into this group. In contrast, countries having particularly many children lacking access to key distance-learning resources and at the same time displaying a substantial learning disadvantage

[10] The correlation between the overall score and the mean z-score of lack of resources is 0.27.

associated with this condition are grouped in the right lower quadrant. Bulgaria stands out. The related learning gap is similarly big in Germany, Slovakia, Hungary and Malta where pupils and schools are better, but still not very well equipped with the important resources, and where these resources matter a lot for learning outcomes. In addition, all of these countries had above average time in school closure (Table 2, last column), leading to long term loss of learning opportunities for the disadvantaged. Clearly, in all these countries, policy makers need to act quickly, to help disadvantaged children not falling further behind.

7 Variation in learning loss

After mapping countries on their likely chances of experiencing a considerable decrease in overall achievement and increase in educational inequalities due the pandemic, it is important to provide some additional information for identifying the source of variations we find.

Our additional regression analyses control also for gender and place of living (urban vs. rural settlement, see Table A5 in the Appendix for results). Generally, across countries these coefficients do not impact much on the importance on resource lack with the exception of some Eastern European countries. Living in a rural area in Latvia, Hungary, Bulgaria, Slovakia and Lithuania is associated with a lower mathematic test score ranging from 15 to 27 than living in cities or bigger towns conditional on parental background, resources and gender. This is to some extent linked with lower parental education and with the lack of at least some of the resources as can be seen from the changing coefficients associated with these variables when place of living was added to the regression models. As a consequence, educational support programs in these countries should pay attention and better target rural areas and schools to mitigate the additional disadvantage that children in these schools suffer.

In Table 1 we reported cross-national differences in schools being equipped for digital learning together with individuals' lack. In Table 2 we provide regression coefficients without having conditioned on school differences, thereby, similarly to Table 1, capturing possible impact of school differences on the results. However, do schools matter in terms of the resource coefficients we examined?

As discussed before, research evidence from some countries shows important between-school differences in the online learning experiences of the students during Covid-19 induced physical school closure. The mode of distance teaching offered by the school was related to the students' socio-economic backgrounds. At the same time, notable variations in the extent to which schools were technically well-equipped existed also before the crisis.

Relying on pre-Covid data, we can of course not be sure that between-school variations in the education provided during distance learning fully match these variations in normal times. We also cannot assume that these variations could be accounted for by the socio-economic differences in students' achievements before and during Covid-19 to the same extent. Still, we argue that it is reasonable to assume a certain correlation between them. In particular, those countries where a significant part of the socio-economic gap in education could be attributed to between-school differences before the pandemic are likely to be the same countries where

unequal responses of the schools to the crisis will further contribute to the increasing education gap.

Figure 5 depicts for each country the coefficients related (1) to parental education from Model 1 (see Table A4 in the Appendix), and (2) the sum of coefficients for parental education and the lack of all school resources (column 7 in Table 2) from Model 2. In addition, the coefficients referring to the same variables are displayed after controlling for school effects (triangle and square shaped markers[11]). In most of the cases, we see the parental coefficient (either through education only or with the effect of resources added) reducing somewhat when we take school fixed effects into account. For the majority of countries however, differences between the schools are not very important factors contributing to the overall socio-economic gap in education in the primary schools. Substantial significant school-effects emerge in some countries with particularly big socio-economic gaps in education, such as Bulgaria, Hungary, Lithuania and Slovakia. In these countries, between school variations account for around 30 to 40% of the educational inequalities related to parental education. The importance of school-differences is also non-negligible in some other places where the gap is not particularly big, most markedly in Germany (26%) and Spain (23%). The patterns are by and large similar when we also take the various resources into account. In countries, where school segregation matters, educational policies aiming at reducing the socio-economic gap in education could already go a long way by targeting disadvantaged schools rather focusing only at families.

Figure 5 about here

8 Discussion and conclusions

While it is commonly assumed that the physical school closure lead to a substantial learning loss for European children during the pandemic, data for examining its actual extent are not available. This paper manoeuvres around the current data lack by using pre-Covid TIMSS 2019 data and applying descriptive statistics, OLS regressions and logical deductions. By doing so and with the obvious limitations this approach entails, it provides to the knowledge of the authors a first cross-national mapping of the likely educational implications of the present crisis in Europe, evaluating both, the overall expected level and inequalities of learning loss.

Our approach of logical deriving conclusions on learning loss from pre-Covid data is much needed as timely information on the actual educational consequences of the crisis are scarce and most likely will remain unavailable for some years at the cross-national European level. We must therefore make the most of pre-Covid information to better understand the serious educational risks involved in the present crisis and to identify groups and countries in the most vulnerable situations.

Since we focus on most vulnerable children, the younger ones who require substantial parental support, we build our analyses to a large extent on the idea of home resources being essential for distance learning and assess how their availability can shape students' learning outcomes during the pandemic. Among these, we account for access to internet, books, having an own room, being hungry regularly and getting parental support. We also examine schools' use of

[11] Details for these models are not presented but available from the authors.

digital resources and management, which serve as proxies for schools' technical preparedness for distance learning

Our approach is as follows. First, we map possible increases in educational inequalities between European countries. We do this by highlighting those countries which are most likely to fall behind given their higher share of children lacking important distance learning resources. Results indicate huge cross-national differences between European countries. In Italy, Bulgaria, France, Croatia, Germany, Cyprus and Czechia relatively many and in Finland, Norway, Denmark, Sweden, Austria, Lithuania and Ireland relatively few students lack important resources for distance learning. The rest of the 22 European countries we examined were situated somewhere in-between.

Second, we examine how important lack of these resources and parental background was for achieving well just before Covid-19 led to physical school closure. In Lithuania, Ireland, Hungary, Bulgaria, Slovakia, Germany, Finland and Malta the association of disadvantage was highest and in Portugal, Denmark, Cyprus, Austria, Croatia, Latvia and Italy it was lowest associated with education outcomes. We argue that while in many countries home learning resources were already important before the pandemic, their importance will be considerably higher during the pandemic. As such, countries who could not counteract inequalities related to parental background and resources are also less likely to fight rising importance of these factors during the pandemic.

In a third step, we merge both, the country patterns of overall lack of resources with their relative importance. Results clearly indicate that in some of those countries which display higher shares of children lacking home resources also their importance for explaining educational outcomes are greater relative to other countries. Consequently, these countries, which comprise Bulgaria, Germany, Slovakia, Hungary and Malta are likely to face substantial decreases in average achievement and increases in inequalities. Unfortunately, as shown by a recent report (Eurydice, 2020) some of these educational systems share some structural characteristics that reduce equity in education.

Our method does not allow us to make precise estimates of either the size of the expected learning loss or the increase in the level of socio-economic gap. However, for both, level of educational outcomes and inequalities, the paper provides a country ranking in terms of expected relative risk of negative outcomes. Since our ranking is based on simple weighting of home and school resources and their association with learning, these rankings come with limitations. Further, several European countries are missing from the sample and thus are not included in this ranking. Nevertheless, it is useful to spot those countries facing serious consequences in schooling outcomes and inequalities due to physical school closures.

Finally, since longer school closures increase the relative risk of decreasing education outcomes and equity, we link our results also to countries' policy on school closure duration. We find that some of those countries at highest risk of low and unequal education outcomes, like Bulgaria and Hungary and Malta, tend to close their schools longest in European comparison and until end February 2021.

Overall, there remains little doubt that the learning loss of 3 percentage points (or 0.08 standard deviations) for a similar age group calculated based on administrative data in the technically advanced and high-income Netherlands after only eight weeks of school closure represents a lower estimate for what we can expect in most of the European countries in this study. Similarly, in several countries with large pre-existing inequalities and longer school closures it is also very likely that the difference in the level of learning loss between children with the highest and the lowest educated parents will exceed the 55% calculated for the Netherlands. (Engzell et. al. 2020)

In order to support today's children overcoming Covid-related learning loss and limited future chances related to them, effective policy support is needed. This should consist both in short-term and longer-term interventions. Short-term programmes should help the most disadvantaged students and their teachers to make the unavoidable distance learning periods more efficient[12], and also to help them to catch up once children return to schools. Longer-term interventions on the other hand should consist not only of monitoring and supporting the progress of this age-group but also of preparing schools and teachers for possible lockdowns in the future. As discussed above, countries at high risk of learning loss are generally those lacking important education system features combatting unequal learning outcomes. Adapting education systems to serve all students (i.e. as discussed in Volante et al., 2019) is also an important long term strategy.

In a final step, our analyses offer some considerations for better targeting such programmes. We find that in several Eastern-European countries (Latvia, Hungary, Bulgaria, Slovakia and Lithuania) a significant urban-rural divide exists, with children in the rural areas being much more likely to be affected by the negative consequences of the crisis. Educational support programmes in these countries could therefore concentrate more on rural areas to mitigate the increase of the educational inequalities. Further, we also show that in a small number of countries – typically in those with large pre-Covid educational inequalities – a significant part of these inequalities can be attributed to differences between schools. This suggests, that in these education systems, targeting worse-achieving schools would go a long way in combatting crisis related low educational achievement.

This paper has a number of limitations which derive entirely from lack of timely data on educational outcomes across Europe. While we identify which children in which countries are of highest risk of low achievement due to Covid-19, we cannot measure the actual extent of educational inequalities. The physical school closure did not only deprive children from learning in schools but also from collecting data on their achievement, as for example the postponement of the for this year planned PISA survey by one year shows. Our limited knowledge and the uncertainty on education outcomes seem not to be of a major concern, perhaps since robust data on health and the economy crowds out what needs to be our dire concern: the future of our children. More efforts need to be made to collect data even at regional level in order to understand the real extent of the pandemic on children's learning. The logical deductions we make show potential for an education crisis in a number of European countries. Lack of data

[12] See for example: https://econpapers.repec.org/paper/izaizadps/dp14094.htm

and monitoring risks to realise the real extent of the problem and to neglect it on the policy agenda until it is too late.

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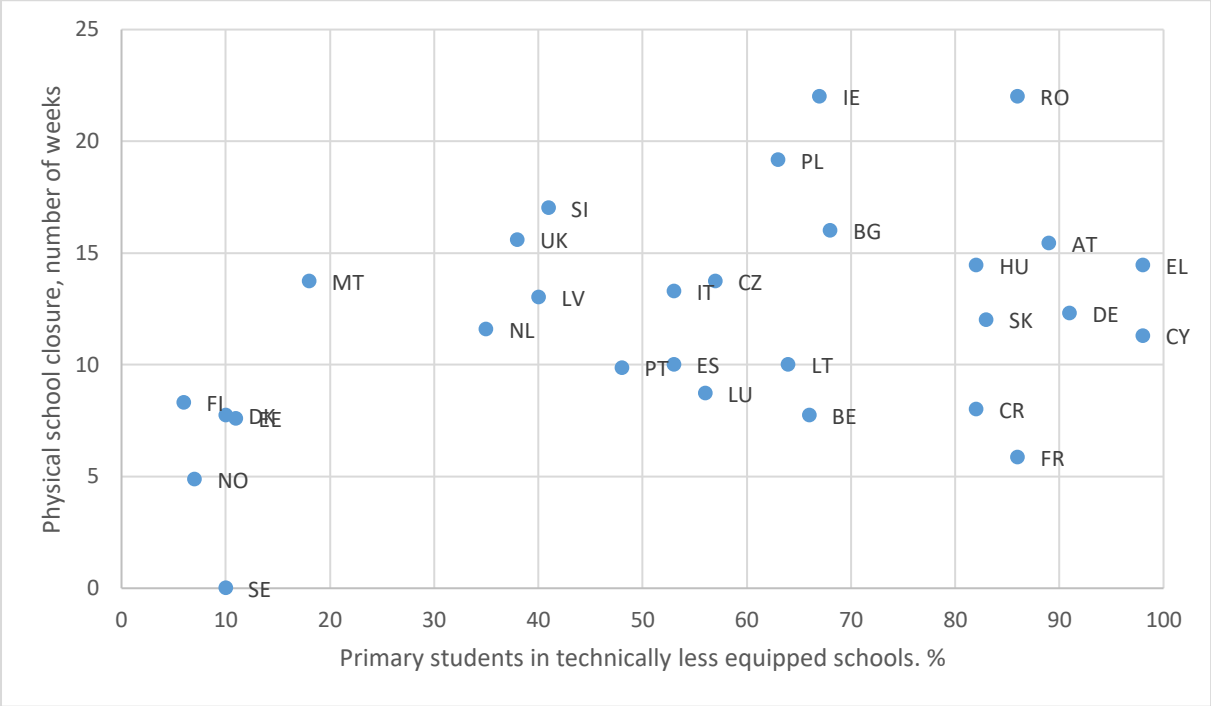
Figures and Tables

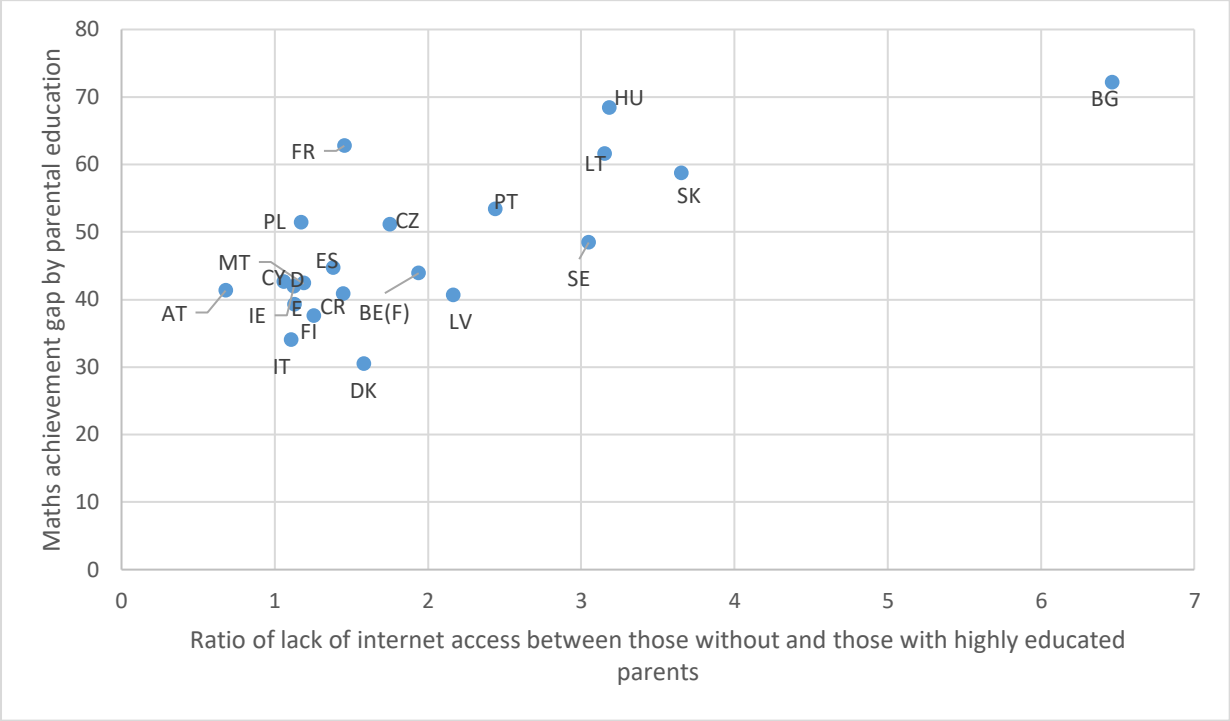
Figure 1: The length of school closures up to 28 February 2021 and the proportion of ISCED1 pupils that study in schools that are at most partially equipped with internet and ICT tools



Source: UNESCO, 2nd Survey of Schools: ICT in Education

Note: Physical school closures are measured by the number of weeks when schools were closed in the entire country due to Covid-19 according to UNESCO. Only data up to 28 February 2021 is included. Internet connection and ICT equipment available in schools are measured through a categorisation based on school surveys in 2017/18. Please refer to footnote 5. Correlation coefficient=0.42.

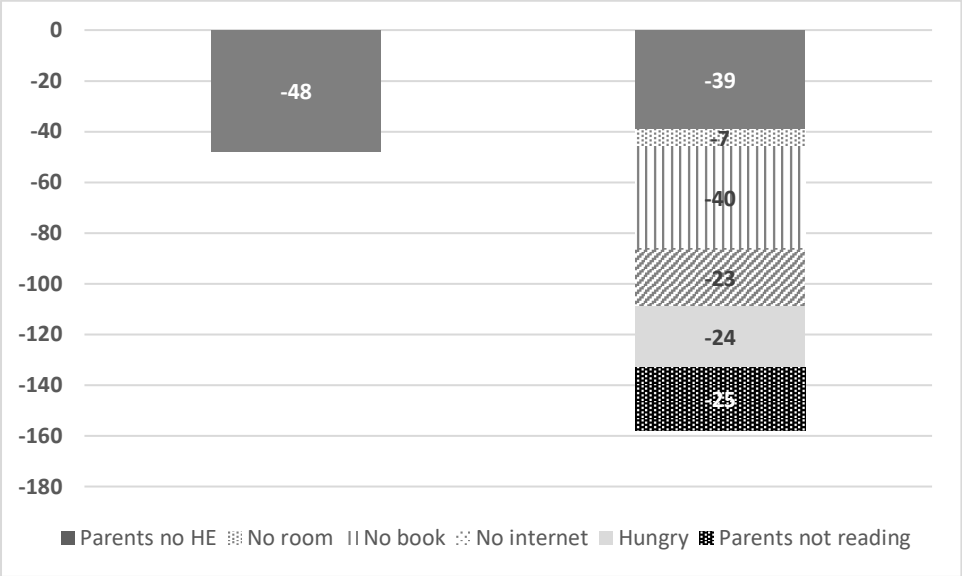
Figure 2: Educational inequalities and socio-economic ratio of lack of internet access in 2019 by country.



Source: TIMSS 2019, authors' calculations

Note: the educational inequalities are differences in TIMSS maths mean achievement between 4th graders who have at least one parent with tertiary education and those whose parents have not completed tertiary education. The socio-economic ratio of lack of internet access derives from dividing the share of disadvantaged pupils who lack access to internet by the share of advantaged pupils who lack access to internet.

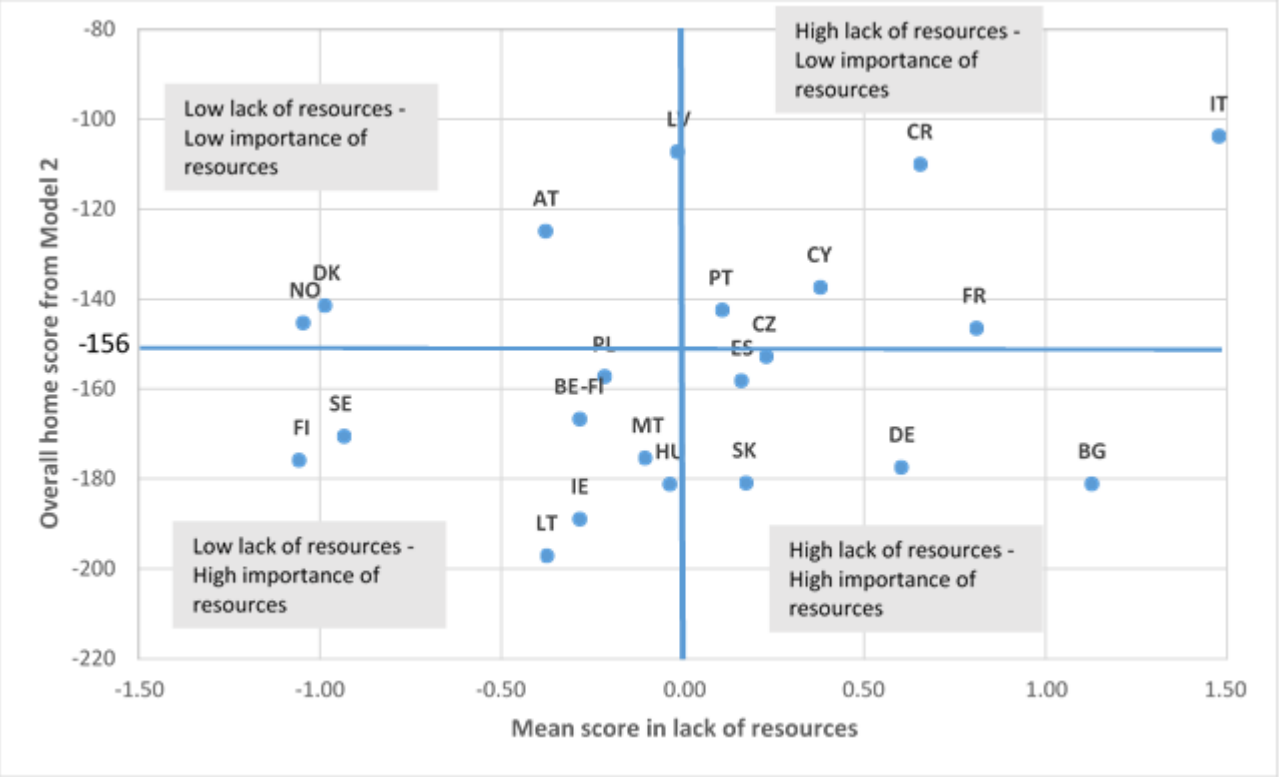
Figure 3: Decline in TIMSS Math achievement score of 4th graders by the individual characteristics lower parental education, no own room, no reading opportunities, no internet access, being hungry and lower parental involvement for 22 European countries in 2019.



Source: TIMSS 2019, authors' calculations

Note: Regression coefficients calculated from Models 1 and 2 on the pooled sample of 22 European countries in the TIMSS 2019 data. Country fixed effects are included in the models. Country data is weighted by population size.

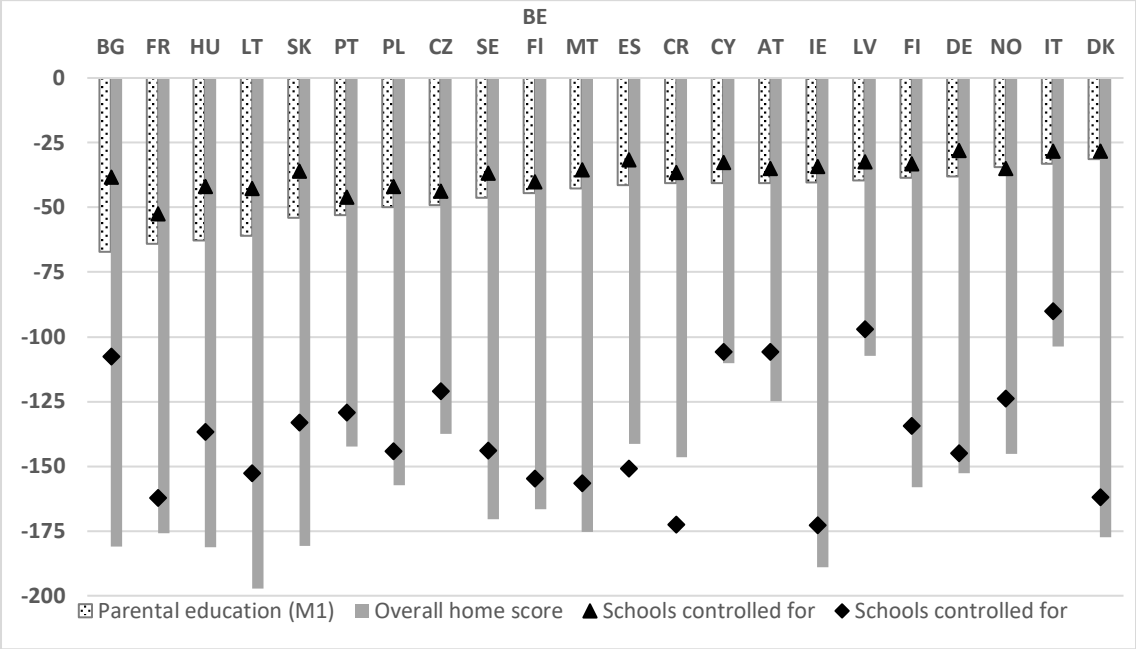
Figure 4: The lack of resources and the overall association between parental education, home resources and mathematical achievement



Source: TIMSS 2019, authors' calculations

Note: The overall home score comes from Model 2 and it equals to the aggregate of the coefficients related to socio-economic background (parental education + home resources). Mean score lack of resources is the country z-score indicating the incidence of children's lack of home resources. Higher values indicate higher incidence.

Figure 5: Reduction in TIMSS mathematical test scores associated with low parental education and with the lack of home resources. Before and after controlling for school effects



Source: TIMSS 2019, authors' calculations

Note: regression coefficients calculated from models M1, M2 and additional models with school fixed effects by country.

Table 1: Percentage of students lacking home and school resources for distance learning, length of school closure and educational achievement before the crisis in various European countries in 2019

	PERCENTAGE STUDENTS LACKING INDIVIDUAL RESOURCES					PERCENTAGE STUDENTS LACKING SCHOOL RESOURCES		SUMMARY INDICATOR		WEEKS SCHOOL CLOSURE	MEAN MATHS TIMSS SCORE
	No Internet at home	No own room	No books and reading device	Regularly hungry in the morning	Limited parental support	No online learning management	Lack access to digital resources	Mean z-score all		up to 28/02/2021	
IT	14	49	5	22	52	49	35	**1,47**		13	515
BG	9	31	10	19	61	22	18	**1,13**		16	515
FR	8	29	3	18	40	82	51	**0,81**		6	485
CR	8	32	4	15	57	50	20	**0,65**		8	509
DE	12	17	3	15	26	81	57	**0,61**		12	521
CY	8	16	4	14	44	78	24	**0,38**		11	532
CZ	4	32	2	17	32	32	46	**0,23**		14	533
SK	4	37	4	15	40	18	22	**0,17**		12	510
ES	7	23	3	14	52	44	9	**0,16**		10	502
PT	4	22	4	13	56	38	16	**0,11**		10	525
LV	4	29	4	15	40	9	19	**-0,01**		13	546
HU	5	25	4	14	32	6	41	**-0,04**		14	523
MT	2	24	1	26	40	16	12	**-0,10**		14	509
PL	9	27	2	9	36	18	14	**-0,22**		19	520
BE (Fl)	4	18	1	13	51	18	12	**-0,29**		8	532
IE	5	24	3	10	28	36	21	**-0,29**		22	548
LT	3	38	3	4	42	1	17	**-0,37**		10	542
AU	3	3	2	14	34	42	32	**-0,38**		15	539
SE	2	15	1	10	33	6	3	**-0,94**		0	521
DK	2	10	1	12	29	0	1	**-0,98**		8	525
NO	1	10	1	10	30	10	4	**-1,05**		5	543
FI	2	18	1	6	25	5	10	**-1,06**		8	532

Source: TIMSS 2019, UNESCO, authors calculations.

Note: Countries are ordered by the summary indicator, which is the countries' mean z-score of all seven home and school variables on its left-hand side (see Appendix Table A.3). No books and reading devices means that students have less than 25 books at home and no digital reading device. Regularly hungry in the morning refers to students who say that they arrive to school hungry every day or almost every day. These answers come from the student questionnaire. Limited parental support is a proxy measure referring to % of students whose parents did not read to them often at pre-school age and comes from the TIMSS contextual questionnaire. No online learning management refers to the responses from the headmasters' questionnaires to the questions 'Does your school use an online learning management system to support learning (e.g., teacher-student communication, management of grades, student access to course materials)?' and 'Does your school provide students access to digital learning resources (e.g., books, videos)?'.

Table 2: The associations between students' home resources and math achievements by country.

	Regression coefficients from M2 models: conditional association between (lack of) the resource and student's Math achievement						Importance of socioeconomic background. Aggregate of coefficients from M2		School closures Nr of weeks up to 28/02/2021
	Parental education	Internet	Own room	Book and reading device	Sufficient breakfast every day	Parental reading to the child	Overall home score	Resources score	
LT	-53.60	*-30.60*	1.8	-57.90	-33.60	-23.20	-197.1	-143.5	10
IE	-33.10	-44.40	-1.00	-46.90	-32.90	-30.70	-188.9	-155.8	22
HU	-53.40	-33.30	-1.60	-60.90	-15.00	-17.10	-181.2	-127.8	14
BG	-50.20	-37.40	-3.50	-32.50	-32.80	-24.80	-181.1	-130.9	16
SK	-42.20	-52.30	5.30	-50.30	-17.40	-23.90	-180.9	-138.7	12
DE	-29.50	-25.10	-18.00	-51.70	-24.20	-28.90	-177.4	-148.0	12
FI	-33.80	*-28.10*	4.00	-56.00	-40.80	-21.20	-175.8	-142.0	8
MT	-36.60	*-34.00*	-3.60	-53.40	-23.20	-24.60	-175.3	-138.8	14
SE	-38.40	-36.70	-24.60	-32.00	-19.00	-19.90	-170.5	-132.1	0
BE-FI	-36.00	-34.50	-14.60	-46.90	-14.90	-20.20	-166.7	-131.1	8
ES	-33.00	-19.00	1.20	-52.90	-31.50	-23.00	-158.1	-125.1	10
PL	-44.40	-35.40	-3.60	*-20.30*	-34.90	-18.80	-157.3	-112.9	19
CZ	-43.30	*-15.90*	0.10	-56.00	-18.70	-19.00	-152.8	-109.4	14
FR	-47.80	-20.20	-19.70	-47.30	-22.00	-31.30	-146.5	-98.7	6
NO	-29.10	-25.80	-8.40	-37.80	*-24.60*	-19.60	-145.3	-116.1	5
PT	-41.90	2.90	-2.90	-50.70	-25.40	-24.50	-142.5	-100.5	10
DK	-27.40	*-31.40*	5.10	-52.70	-12.30	-22.80	-141.5	-114.0	8
CY	-32.90	-24.50	3.50	-34.50	-32.20	-16.80	-137.4	-104.5	11
AT	-34.10	*-19.40*	*-9.60*	-16.70	-20.60	-24.40	-124.9	-90.8	15
CR	-34.40	-24.50	4.4	-13.30	-19.30	-23.00	-110.1	-75.7	8
LV	-33.90	*-16.30*	2.20	-20.30	-17.10	-21.80	-107.2	-73.3	13
IT	-26.10	-16.60	4.70	-26.70	-20.10	-19.10	-103.8	-77.7	13

Source: UNESCO, TIMSS 2019, authors' calculations

Notes: Regression coefficients come from M2. Level of significance of the coefficients is marked: ***p<0.01****, p<0.05, p<0.1. Countries are ranked by the Overall home score which is the aggregate of the coefficients related to socio-economic background (parental education + home resources).*

Appendix

Table A1: Sample sizes and missing value statistics

	N		% missing					
	N original sample	N sample of the models	Parental education	Own room	Book and reading device	Internet	Hungry in the mornings	Parents do not read often
AT	4464	3630	11.60	0.76	1.66	0.87	4.14	10.19
BE-Fl	4655	3753	10.40	0.75	1.12	0.97	2.26	4.92
BG	4268	3842	3.49	0.77	1.38	1.38	3.66	2.81
CR	3785	3397	2.25	0.87	3.04	1.32	3.01	2.19
CY	4062	3363	9.48	0.94	1.30	1.01	3.15	5.02
CZ	4692	3484	17.03	4.88	5.37	5.01	8.76	16.18
DE	3437	1643	35.44	13.91	16.67	14.98	22.81	34.57
DK	3227	1566	42.14	1.36	2.32	1.36	3.07	40.78
ES	9555	7540	11.68	1.49	2.32	1.97	4.96	10.76
FI	4730	4005	12.35	1.10	1.65	1.29	2.05	11.75
FR	4186	3358	10.68	4.68	4.99	5.09	6.55	8.93
HU	4571	3636	9.43	2.30	3.39	2.43	5.93	9.17
IE	4582	3883	6.66	1.68	2.77	1.94	6.68	6.07
IT	3741	3082	9.81	0.78	2.03	0.80	4.36	5.03
LT	3741	2750	18.95	3.80	4.04	4.04	5.32	17.43
LV	4481	3915	7.68	1.32	1.45	1.34	3.01	4.04
MT	3630	2461	29.28	0.41	1.87	0.50	2.15	27.38
NO	3951	1643	41.00	5.04	5.59	4.83	7.54	40.75
PL	4882	4119	6.55	1.33	2.52	1.66	5.88	5.06
PT	4300	3625	6.56	1.00	1.77	1.35	6.35	5.60
SE	3965	2593	23.00	2.24	3.58	2.07	4.62	18.13
SK	4247	3818	4.52	0.87	1.39	0.94	3.11	4.24
Pooled	**97152**	**75106**	**14.09**	**2.24**	**3.11**	**2.47**	**5.30**	**12.37**

Table A2: Percentage of 4th graders not having access to the various home resources by parental education and country. TIMSS 2019 data. Statistically significant differences marked with bold, p<0.05

	No internet %			No own room %			No books or reading device %			Hungry almost every day %			Parents not reading to child %		
	All	Parents without HE	Parents with HE	All	Parents without HE	Parents with HE	All	Parents without HE	Parents with HE	All	Parents without HE	Parents with HE	All	Parents without HE	Parents with HE
AT	3	3	4	23	**22**	**19**	2	**2**	**1**	14	**15**	**12**	34	**38**	**16**
BG	9	**13**	**2**	31	**34**	**26**	10	**14**	**2**	19	21	18	61	**73**	**40**
CR	8	9	6	32	**34**	**28**	4	**5**	**1**	15	16	15	57	**65**	**41**
CY	8	8	7	16	**18**	**12**	4	**6**	**1**	14	**17**	**12**	44	**56**	**31**
CZ	4	**5**	**3**	32	**29**	**34**	2	**3**	**0**	17	**17**	**13**	32	**38**	**22**
DK	2	3	2	10	9	5	1	1	1	12	11	11	29	**41**	**24**
FI	2	2	1	18	**22**	**14**	1	1	0	6	7	6	25	**36**	**17**
FR	8	**8**	**6**	29	**32**	**20**	3	**3**	**0**	18	**21**	**13**	40	**52**	**18**
DE	12	12	10	17	15	13	3	**3**	**1**	15	**17**	**9**	26	**31**	**15**
HU	5	**6**	**2**	25	**27**	**21**	4	**6**	**1**	14	14	12	32	**43**	**13**
IE	5	5	4	24	24	23	3	**4**	**1**	10	11	9	28	**36**	**18**
IT	14	15	13	49	50	47	5	**5**	**2**	22	23	19	52	**60**	**32**
LV	4	**6**	**3**	29	**31**	**26**	4	**6**	**2**	15	15	15	40	**50**	**31**
LT	3	**5**	**2**	38	**44**	**32**	3	**5**	**1**	4	4	4	42	**53**	**32**
MT	2	2	1	24	24	25	1	1	1	26	**26**	**21**	40	**46**	**24**
NO	1	1	1	10	**13**	**4**	1	0	0	10	9	9	30	**46**	**22**
PL	9	9	8	27	**32**	**22**	2	**3**	**1**	9	10	8	36	**47**	**25**
PT	4	**5**	**2**	22	21	22	4	**5**	**1**	13	**14**	**10**	56	**69**	**35**
SK	4	**6**	**2**	37	**41**	**31**	4	**6**	**0**	15	**17**	**12**	40	**51**	**22**
ES	7	**7**	**5**	23	**19**	**25**	3	**4**	**1**	14	**15**	**11**	52	**61**	**39**
SE	2	**2**	**1**	15	**17**	**9**	1	1	1	10	**10**	**7**	33	**43**	**20**
BE (Fl)	4	**5**	**3**	18	**25**	**12**	1	0	0	13	**15**	**12**	51	**66**	**39**

Table A3: Z-scores calculated for each country on the basis of the percentage of students not having access to the various resources. TIMSS 2019 data

	INDIVIDUAL RESOURCES (% of students lacking the resource, TIMSS data)					SCHOOL RESOURCES (% of students in schools without the resource, TIMSS data)	
	Internet	Own room	Book and reading device	Sufficient breakfast every day	Parental reading to the child	Online learning management	Access to digital resources
AU	1.10	0.65	3.58	1.13	1.98	-0.32	-0.24
BE (Fl)	-0.20	0.05	0.43	-0.09	-0.75	-0.94	1.24
BG	0.61	0.44	-0.15	0.90	-0.03	2.02	1.86
CR	-0.69	1.35	-0.03	-1.95	0.21	-1.15	-0.34
CY	-0.29	1.23	0.48	0.24	0.00	-0.46	0.00
CZ	-0.47	-0.21	0.31	-0.27	1.48	0.29	-0.39
DE	0.91	0.30	-0.31	-1.08	-0.35	-0.48	-0.50
DK	-0.30	0.78	-0.49	0.69	-0.72	0.06	1.55
ES	-1.06	-0.85	-0.93	-0.89	-0.70	-0.94	-1.20
FI	-0.45	-0.53	-0.85	-0.11	1.07	-0.48	-0.65
FR	-0.94	0.01	-0.90	2.38	-0.03	-0.55	-0.67
HU	0.38	-0.11	0.13	-0.02	1.09	0.54	-0.87
IE	0.65	-0.80	0.37	0.05	0.33	1.86	0.14
IT	-0.19	-0.02	-0.06	-0.81	-1.08	0.25	-0.09
LT	-0.71	-1.99	-0.51	0.05	-0.58	0.48	0.61
LV	0.75	0.74	0.54	0.29	1.58	0.79	-0.12
MT	-0.29	0.42	0.47	0.30	-0.01	-0.81	-0.17
NO	-1.04	-0.55	-1.12	-1.55	-1.38	-0.96	-0.79
PL	-1.24	-1.35	-1.11	-0.83	-0.89	-0.76	-1.14
PT	1.82	-0.65	-0.06	0.23	-1.33	1.98	2.25
SE	2.61	2.39	0.95	1.66	1.10	0.74	0.85
SK	-0.98	-1.31	-0.75	-0.33	-1.01	-1.17	-1.34

Table A4: Decline in TIMSS achievement score for lower parental education (M1) and with low parental education, no own room, no reading opportunities, no internet access, going to school hungry and lower parental involvement (M2). Pooled sample and 22 European countries in 2019 by country

	Pooled sample	AT	BG	HR	CY	CZ	DK	FI	FR	DE	HU	IE	IT	LV	LT	MT	NO	PL	PT	SK	ES	SE	BE Fl
M1																							
Parental education	47.84***	40.49***	67.05***	40.72***	40.68***	49.03***	31.46***	38.65***	64.04***	38.07***	62.73***	40.35***	33.23***	39.51***	60.93***	42.66***	34.50***	50.01***	52.94***	53.99***	41.31***	46.29***	44.44***
	(1.370)	(3.064)	(6.387)	(3.268)	(3.784)	(3.331)	(4.912)	(3.192)	(3.246)	(4.414)	(3.899)	(3.041)	(3.032)	(3.279)	(3.818)	(3.144)	(6.275)	(3.460)	(3.169)	(4.251)	(3.792)	(4.475)	(3.094)
Constant	532.2***	534.2***	498.2***	499.0***	516.3***	524.7***	517.3***	513.7***	466.1***	523.5***	506.4***	537.9***	509.6***	528.9***	513.2***	504.5***	531.5***	501.6***	511.1***	492.8***	491.6***	508.0***	510.9***
	(2.121)	(2.186)	(6.014)	(2.498)	(3.421)	(2.511)	(4.994)	(3.045)	(2.894)	(3.411)	(3.301)	(2.561)	(2.701)	(3.277)	(3.240)	(1.962)	(5.681)	(3.035)	(2.772)	(3.664)	(3.459)	(3.587)	(2.878)
Observations	75,106	3,63	3,842	3,397	3,363	3,484	1,566	4,005	3,358	1,643	3,636	3,883	3,082	3,915	2,75	2,461	1,643	4,119	3,625	3,818	7,54	2,593	3,753
Adjusted R-squared	0.171	0.091	0.168	0.094	0.077	0.123	0.043	0.070	0.172	0.082	0.176	0.082	0.063	0.094	0.173	0.082	0.056	0.122	0.135	0.139	0.093	0.111	0.119
M2																							
Parental education	38.62***	34.10***	50.19***	34.35***	32.88***	43.33***	27.42***	33.80***	47.77***	29.48***	53.37***	33.10***	26.09***	33.96***	53.64***	36.58***	29.11***	44.35***	41.93***	42.20***	33.00***	38.39***	35.60***
	(1.274)	(2.913)	(4.288)	(3.194)	(3.827)	(3.273)	(4.943)	(3.257)	(3.243)	(4.334)	(3.427)	(3.093)	(3.019)	(3.033)	(3.793)	(3.180)	(5.530)	(3.168)	(3.310)	(3.679)	(3.443)	(4.354)	(2.966)
No room	-6.787***	-9.529**	-3.525	4.366	3.534	0.0707	5.103	3.957	-19.72***	-18.04***	-1.569	-1.016	4.708	2.176	1.802	-3.580	-8.357	-3.633	-2.852	5.252	1.178	-24.56***	-14.59***
	(1.373)	(3.663)	(4.198)	(3.246)	(4.248)	(3.050)	(10.10)	(3.938)	(3.799)	(5.568)	(3.584)	(3.570)	(2.865)	(3.033)	(3.486)	(3.057)	(10.86)	(3.719)	(3.249)	(3.247)	(3.430)	(6.330)	(3.499)
No books or device	-40.00***	-16.74	-32.45***	-13.27	-34.53***	-56.00***	-52.74**	-56.01***	-47.27***	-51.74***	-60.91***	-46.83***	-26.68***	-20.26***	-57.87***	-53.42***	-37.80	-20.27**	-50.68***	-50.28***	-52.88***	-31.95**	-46.90***
	(3.196)	(11.24)	(10.99)	(13.50)	(7.680)	(14.16)	(22.14)	(17.24)	(8.225)	(13.01)	(8.824)	(8.156)	(6.609)	(6.871)	(12.98)	(19.03)	(42.19)	(8.711)	(7.590)	(13.07)	(10.72)	(13.97)	(12.55)
No internet	-22.85***	-19.44**	-37.37***	-24.51***	-24.48***	-15.88**	-31.40**	-28.07**	-20.16***	-25.05***	-33.30***	-44.39***	-16.56***	-16.31**	-30.57**	-34.01**	-25.81	-35.36***	2.887	-52.29***	-18.96***	-36.68**	-34.47***
	(2.178)	(7.869)	(9.617)	(7.113)	(5.548)	(7.726)	(12.54)	(12.95)	(7.307)	(5.866)	(9.564)	(6.809)	(4.149)	(7.686)	(13.18)	(13.27)	(33.06)	(5.345)	(7.769)	(10.41)	(5.279)	(15.90)	(6.354)
Hungry every day	-24.42***	-20.64***	-32.78***	-19.26***	-32.18***	-18.65***	-12.26*	-40.76***	-22.00***	-24.22***	-14.99***	-32.94***	-20.07***	-17.06***	-33.62***	-23.18***	-24.57**	-34.85***	-25.37***	-17.44***	-31.51***	-19.03***	-14.93***
	(1.263)	(4.070)	(4.885)	(4.662)	(4.325)	(4.719)	(7.252)	(6.429)	(3.355)	(5.421)	(4.980)	(6.551)	(3.613)	(3.460)	(7.970)	(3.424)	(9.840)	(4.558)	(3.508)	(4.515)	(4.851)	(4.767)	(3.623)
Parents not read often	-24.70***	-24.44***	-24.81***	-23.03***	-16.84***	-18.99***	-22.75***	-21.16***	-31.31***	-28.91***	-17.07***	-30.66***	-19.11***	-21.83***	-23.22***	-24.56***	-19.61***	-18.80***	-24.53***	-23.91***	-22.97***	-19.89***	-20.19***

Constant	(1.025) 548.7*** (2.018)	(2.636) 549.4*** (2.418)	(2.930) 532.8*** (4.222)	(3.691) 518.2*** (3.127)	(2.843) 534.5*** (3.905)	(3.438) 537.3*** (2.754)	(4.052) 528.8*** (5.113)	(3.709) 524.4*** (3.242)	(3.434) 496.2*** (3.377)	(4.212) 543.6*** (4.101)	(4.030) 521.0*** (2.983)	(3.194) 556.4*** (2.790)	(2.799) 526.9*** (3.158)	(2.772) 543.9*** (3.180)	(3.236) 530.0*** (3.666)	(3.029) 523.5*** (2.527)	(6.354) 544.4*** (5.157)	(2.992) 518.0*** (2.861)	(2.930) 534.3*** (3.271)	(3.221) 511.4*** (3.464)	(2.894) 513.3*** (3.754)	(3.870) 523.8*** (3.788)	(2.465) 532.4*** (2.872)
Observations	75,106	3,63	3,842	3,397	3,363	3,484	1,566	4,005	3,358	1,643	3,636	3,883	3,082	3,915	2,75	2,461	1,643	4,119	3,625	3,818	7,54	2,593	3,753
Adjusted R-squared	0.234	0.154	0.268	0.154	0.131	0.163	0.075	0.111	0.255	0.192	0.230	0.174	0.124	0.137	0.234	0.142	0.086	0.177	0.194	0.226	0.172	0.158	0.178

Table A5: Decline in TIMSS achievement score for lower parental education and with low parental education, no own room, no reading opportunities, no internet access, going to school hungry and lower parental involvement with controls for gender and urban vs. rural place of living. Models M1a and M2a. Pooled sample and 22 European countries in 2019 by country

	Pooled	AT	BG	HR	CY	CZ	DK	FI	FR	DE	HU	IE	IT	LV	LT	MT	NO	PL	PT	SK	ES	SE	BEFI
M1a																							
Parental education	47.69***	42.67***	58.31***	39.11***	40.60***	49.30***	31.09***	38.64***	64.62***	37.68***	56.91***	40.99***	33.49***	36.90***	52.13***	42.28***	33.03***	49.18***	53.48***	47.63***	39.99***	45.69***	44.05***
	(1.364)	(3.072)	(5.032)	(3.344)	(3.562)	(3.254)	(5.007)	(3.181)	(3.189)	(4.100)	(3.904)	(3.062)	(3.090)	(3.030)	(3.560)	(3.083)	(6.105)	(3.714)	(3.201)	(3.384)	(3.398)	(4.394)	(3.207)
Rural	0.405	13.41***	-26.84***	-4.312	-0.696	-0.149	-6.507	0.496	6.296	0.451	-20.08***	9.717*	3.522	-15.59***	-32.22***	7.358**	-7.647	-1.411	5.185	-22.77***	-6.291	-1.745	10.82***
	(1.808)	(3.787)	(9.026)	(4.354)	(5.640)	(4.253)	(6.647)	(3.681)	(4.883)	(5.761)	(4.704)	(5.033)	(4.835)	(4.931)	(6.330)	(3.001)	(7.245)	(5.030)	(6.142)	(4.977)	(8.397)	(5.776)	(3.762)
Girls	-12.92***	-8.456***	-3.736	-12.06***	-22.01***	-15.02***	-9.844**	-3.128	-15.86***	-15.55***	-10.24***	-8.193**	-11.75***	-6.927**	-1.335	-10.37***	-1.922	-10.40***	-19.46***	-14.13***	-15.73***	-9.113**	-12.44***
	(1.239)	(3.056)	(3.226)	(3.434)	(2.929)	(2.931)	(4.025)	(3.335)	(3.114)	(3.855)	(2.900)	(3.253)	(3.854)	(3.022)	(3.250)	(2.975)	(5.992)	(2.757)	(2.732)	(3.462)	(3.074)	(3.805)	(3.288)
Constant	538.6***	531.5***	513.9***	507.6***	528.1***	532.1***	525.3***	514.9***	470.8***	531.4***	523.0***	536.6***	513.4***	539.4***	526.6***	505.7***	537.2***	508.1***	519.5***	515.4***	501.0***	513.9***	510.6***
	(2.248)	(2.869)	(4.909)	(3.543)	(3.632)	(3.210)	(7.024)	(3.533)	(4.090)	(4.195)	(4.234)	(4.535)	(4.831)	(3.580)	(3.708)	(3.025)	(7.966)	(4.773)	(3.125)	(4.023)	(3.204)	(4.919)	(4.330)
Observations	75,106	3,63	3,842	3,397	3,363	3,484	1,566	4,005	3,358	1,643	3,636	3,883	3,082	3,915	2,75	2,461	1,643	4,119	3,625	3,818	7,54	2,593	3,753
Adjusted R-squared	0.180	0.108	0.193	0.104	0.099	0.135	0.050	0.070	0.184	0.096	0.198	0.089	0.072	0.110	0.205	0.090	0.058	0.126	0.154	0.172	0.108	0.115	0.136
M2 + controls																							
Parental education	38.19***	35.61***	45.16***	32.90***	32.70***	43.47***	27.18***	33.79***	47.76***	28.41***	48.67***	33.36***	26.11***	31.48***	46.76***	36.13***	27.56***	43.62***	41.99***	37.05***	31.88***	37.14***	35.30***
	(1.251)	(2.934)	(3.842)	(3.194)	(3.567)	(3.141)	(4.988)	(3.264)	(3.175)	(4.075)	(3.555)	(3.124)	(3.049)	(2.875)	(3.642)	(3.112)	(5.529)	(3.433)	(3.332)	(3.083)	(3.081)	(4.252)	(3.112)
No room	-6.330***	-7.342**	-4.658	-4.854	-4.081	-0.407	-4.159	-4.136	-19.03***	-17.58***	-1.593	-0.0414	-5.528*	-0.758	-1.850	-2.472	-10.14	-3.810	-1.987	-6.980**	-2.011	-25.71***	-13.06***
	(1.371)	(3.592)	(4.244)	(3.277)	(3.988)	(3.034)	(10.19)	(3.922)	(3.714)	(5.381)	(3.553)	(3.296)	(2.886)	(3.164)	(3.267)	(3.090)	(10.61)	(3.702)	(3.187)	(3.207)	(3.121)	(6.279)	(3.401)
No books or device	-40.45***	-17.01	-29.02***	-14.48	-34.06***	-56.45***	-52.48**	-55.75***	-46.25***	-51.70***	-58.33***	-48.04***	-27.52***	-21.16***	-51.87***	-53.49***	-39.48	-21.24**	-51.01***	-47.94***	-53.61***	-35.60**	-45.98***
	(3.241)	(10.77)	(10.67)	(13.27)	(7.702)	(13.87)	(21.43)	(17.55)	(8.326)	(12.63)	(8.701)	(8.134)	(6.488)	(6.550)	(12.76)	(19.00)	(42.15)	(8.662)	(7.564)	(13.52)	(11.06)	(13.98)	(11.63)
No internet	-22.59***	-20.41**	-35.07***	-23.74***	-22.79***	-15.50**	-30.39**	-27.99**	-18.73**	-24.37***	-30.97***	-43.66***	-17.10***	-15.70**	-26.91*	-34.57**	-23.53	-35.54***	-4.566	-52.43***	-18.19***	-35.68**	-34.72***

	(2.169)	(7.853)	(9.137)	(7.018)	(5.392)	(7.513)	(12.75)	(12.83)	(7.122)	(5.961)	(9.592)	(6.844)	(4.088)	(7.642)	(13.66)	(13.27)	(32.26)	(5.205)	(8.116)	(10.22)	(5.386)	(16.21)	(6.080)
Hungry every day	-25.63***	-21.21***	-32.53***	-20.57***	-34.46***	-19.47***	-13.52*	-41.52***	-22.97***	-25.37***	-14.87***	-33.34***	-21.18***	-18.24***	-33.92***	-23.90***	-25.03**	-36.76***	-26.80***	-19.32***	-33.30***	-19.58***	-16.24***
	(1.238)	(3.871)	(4.732)	(4.594)	(4.232)	(4.705)	(7.156)	(6.461)	(3.354)	(5.320)	(5.083)	(6.546)	(3.628)	(3.443)	(8.313)	(3.434)	(10.01)	(4.512)	(3.438)	(4.551)	(4.862)	(4.803)	(3.753)
Parents not read often	-25.28***	-24.16***	-23.55***	-23.92***	-17.35***	-18.96***	-22.78***	-21.28***	-31.86***	-29.98***	-16.76***	-30.92***	-19.64***	-21.32***	-21.91***	-24.86***	-19.57***	-19.12***	-25.41***	-23.93***	-23.59***	-20.18***	-20.79***
	(1.014)	(2.659)	(2.997)	(3.565)	(2.769)	(3.328)	(4.118)	(3.672)	(3.363)	(4.077)	(4.035)	(3.280)	(2.714)	(2.688)	(3.199)	(3.046)	(6.247)	(3.016)	(2.875)	(3.253)	(2.809)	(3.825)	(2.416)
Rural	-0.0227	8.525**	-18.41**	-2.589	-0.166	-0.736	-4.977	1.000	1.635	-2.458	-17.06***	6.870	3.599	-15.12***	-27.31***	7.087**	-7.455	-0.0958	3.768	-19.11***	-3.679	-4.874	7.527**
	(1.614)	(3.634)	(7.084)	(4.259)	(5.545)	(4.105)	(6.522)	(3.537)	(4.426)	(5.087)	(4.399)	(4.771)	(4.437)	(4.769)	(6.115)	(2.843)	(7.002)	(4.685)	(6.078)	(4.545)	(7.619)	(5.652)	(3.429)
Girls	14.75***	10.86***	6.683**	14.75***	23.55***	15.57***	10.85***	-4.880	16.69***	17.05***	10.64***	10.86***	14.46***	8.098***	-2.795	12.06***	-4.433	12.93***	21.30***	17.94***	18.46***	10.30***	14.65***
	(1.185)	(2.921)	(3.150)	(3.486)	(2.856)	(2.797)	(3.819)	(3.232)	(2.842)	(3.940)	(2.861)	(2.895)	(3.710)	(2.865)	(3.320)	(2.886)	(5.747)	(2.714)	(2.587)	(2.983)	(2.855)	(3.535)	(3.232)
Constant	556.6***	550.0***	544.3***	527.9***	547.4***	545.2***	536.8***	526.3***	503.9***	554.3***	535.7***	558.1***	532.4***	555.2***	541.0***	525.7***	551.5***	525.4***	544.6***	532.8***	523.6***	532.4***	535.5***
	(2.117)	(3.090)	(4.295)	(3.827)	(3.957)	(3.412)	(6.995)	(3.846)	(4.456)	(4.609)	(4.184)	(4.431)	(5.110)	(3.759)	(4.399)	(3.435)	(7.654)	(4.567)	(3.448)	(4.338)	(3.126)	(4.859)	(4.301)
Observations	75,106	3,63	3,842	3,397	3,363	3,484	1,566	4,005	3,358	1,643	3,636	3,883	3,082	3,915	2,75	2,461	1,643	4,119	3,625	3,818	7,54	2,593	3,753
Adjusted R-squared	0.245	0.166	0.281	0.168	0.156	0.175	0.082	0.112	0.267	0.209	0.247	0.182	0.138	0.153	0.257	0.152	0.088	0.184	0.216	0.259	0.191	0.164	0.195

Note: standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1