Investigating the "second digital divide" across European countries: social disparities on digital reading and navigation skills

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1. Introduction

In the information age, equal access and use of Information and Communication Technologies (ICTs) has become a major policy objective in most industrialised countries. Following years of considerable public and private investments in ICTs, the “first digital divide”—i.e., the socioeconomic gap in physical access to ICTs—has been shrinking almost everywhere. Major concerns are now posed by the so called “second digital divide”—i.e., the socioeconomic gap in use and ability to take full advantage of ICTs. While the amount of time that students spend on the computer does not differ widely across socioeconomic groups, what students do with computers (from using e-mail to reading news on the Internet, etc.) appears to be related to students’ social background (OECD, 2015a). Given the increasing centrality of information and diffusion of ICTs, proficiency in using the new technologies has become a key asset for a full and active participation in economic, social and civic life.

This report aims at shedding light on the second digital divide in European countries with a specific focus on youths’ digital reading skills. In nearly all domains, today information is produced and spread by the means of technological devices rather than printed documents. This technological innovation demands changes in the set of skills individuals have to develop in order to adequately benefiting and exploiting such information. Reading online texts requires

new competences that go beyond "traditional" skills needed for printed documents (Noyes and Garland, 2003; Mangen et al., 2013; OECD, 2015a). First, online texts are characterised by a combination of text, images, animations, videos, etc. Also, hyper-links are often embedded in online texts, this creating non-sequential page structures. This complex configuration requires readers to possess adequate text-processing skills and ability to navigate through different texts (OECD, 2015a). Web pages also require organisational and spatial skills, such as the ability to construct a mental representation of the structure of a website in order to move confidently across the different pages (OECD, 2015a). Second, evaluative skills are also particularly important for online text forms. Individuals have to assess the relevance of information and the credibility of sources by using their prior experience and hints provided by the web pages (e.g., layout, poor grammar and spelling, link names, etc.). Hence, the use of digital information requires individuals to develop a set of specific competences that range from knowing the sources of information, knowing how to search and find the relevant information, being able to critically examining and assessing internet information sources. In sum, digital reading competences involve both "print" reading skills and a set of new digital competences that can be labelled as "navigation skills". The extent to which the former or the latter prevail in forming digital reading proficiency is a matter of empirical investigation. Empirical research in this area might convey useful indications on the extent to which the education systems and schools should integrate these “new” skills in the curricula alongside more “traditional” subjects.

While there is an abundant literature on social inequality with respect to “traditional” measures of educational performance (e.g., reading and mathematics skills above all), our knowledge on the existence of social disparities in the (proficiency of) use of new digital skills is still scarce. Recent studies (OECD, 2015a, 2015b; Cruz-Jesus et *al.*, 2016) provide some hints that social disparities are not confined to the traditional areas of educational performance but might also involve these new digital skills. The aim of this report is to shed further light on the topic by analysing PISA 2012 Computer Based Assessment data relative to 15 European Union (EU) countries (Austria, Belgium, Germany, Denmark, Spain, Estonia, France, Hungary, Ireland, Italy, Poland, Portugal, Slovakia, Slovenia, Sweden), plus Israel and Norway. The remaining EU countries are not included in the analysis as they did not administer the digital reading tests.

First, the report assesses the existence of disparities in digital reading (Section 2). We focus on the roles played by gender, migration background and social origins (as measured by parental education and occupation) as these factors have been found to influence youths’ use and confidence with ICTs (Livingstone & Helsper, 2007; Notten *et al.*, 2009). We compare "gross" gaps and "net" gaps, the latter being estimated holding print reading skills constant. This analysis allows us to identify, and quantify, the existence of social disparities in digital reading that go over and beyond standard (print) reading skills and that can be related to disparities in "navigation skills". Overall, results show that the greatest part of the differences in digital reading are due to group differences in print reading. Hence, inequality in digital reading is greatly attributable to students’ development of standard reading competences and not to digital ones. Nonetheless, some significant gaps in digital reading persist across groups even net of print reading skills, this pointing to the existence of “digital-specific” gaps. The case of gender differences is noteworthy, as it reveals that boys underperform girls on the digital reading test but, when print reading skills are equalised across genders, their “disadvantage” turns into an “advantage”, suggesting that boys are more proficient with computers and ICTs.

In Section 3, navigation skills are closely examined considering two distinct indices that measure students’ behaviours when taking the PISA computer-based digital reading test. The first index reports students' *overall browsing activity*, hence a "quantitative" measure of students' interaction with the computer during the examination. Of course, the quantity of browsing might not only indicate digital proficiency but also unfocused reading and inefficiency (OECD, 2015a). The second index (*targeted navigation*), instead, provides also a measure of the quality of students' navigation. By taking “right” and “wrong” steps into account, this index captures students’ reflective behaviour in answering the computer tests (“think, then click”

approach) (OECD, 2015a). Overall the results indicate that, net of print reading competences, the four individual attributes considered (gender, migration background, parental education and occupation) play a substantially small role on students' navigation skills, although in some countries differences due to social background are noticeable. Regarding gender gaps, it is worth emphasizing that boys do indeed show significantly higher navigation activity levels than girls, but when considering the quality of navigation, they fall behind girls. This result point to the existence of gendered approaches to ICTs and the internet, with boys being more "technically" capable to interact with computers but at the same time being more unfocused, while girls appear to be more reflective. Beyond documenting the existence of disparities on these navigation skills, the report also shows that these gaps may be related to group differences in ICT familiarity, given by the age of first exposure to ICT, frequency and patterns of use of computers and the internet, as well as attitudes towards the use of ICT in education.

In Section 4, the focus is shifted to the role that schools and the education systems play in shaping students' digital skills. Providing causal estimates on the role of these factors is far beyond the scope of this report, hence the results presented in this report are to be considered as an attempt to establish some statistical descriptive regularities on the topic. The findings seem to indicate that digital gaps are correlated with some features of the national education systems—such as the overall quality of the education system—but that, in general, digital skills are more dependent on individual characteristics of the students rather than on schools' factors.

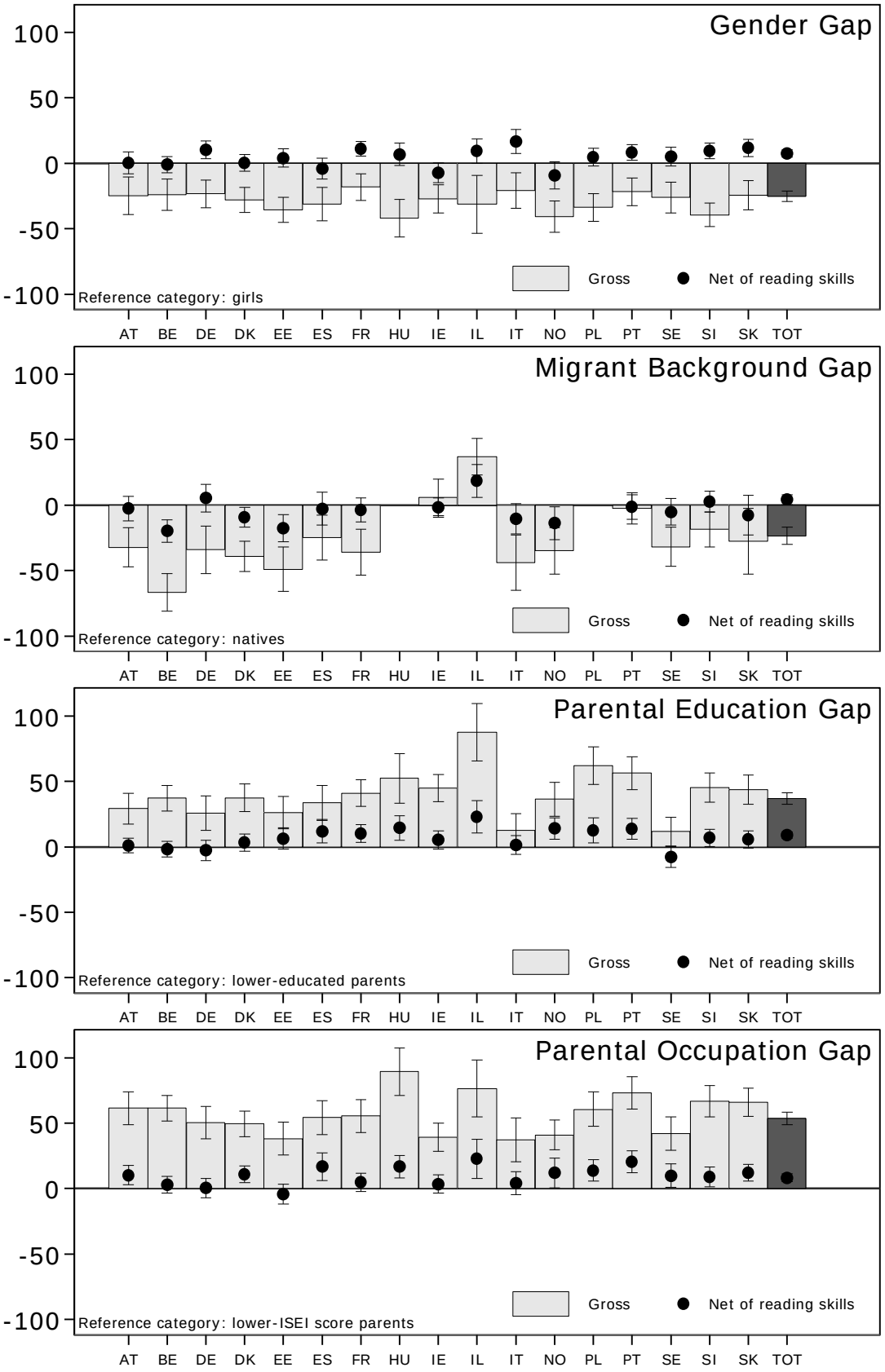
Section 5 concludes, summarising and discussing the main findings of the study.

2. Gaps in digital reading

In this section, three questions are addressed. First, is there evidence of digital reading gaps arising from gender, migration background and social background? Second, are the gaps persisting after holding print reading skills constant across groups? And, third, are there country variations in the results?

To answer these questions, a series of linear regression models is estimated both on the pooled set of countries and within each distinct country. These models are aimed at estimating digital reading score mean differences between groups identified by the four ascriptive factors that were considered in the analysis. More precisely, the "gender gap" is boys' average score minus the girls' scores, hence negative values indicate boys underperforming girls. The migrant background gap is obtained subtracting natives' scores from the children of immigrants' ones, with positive values indicating children of immigrants performing better than natives. The parental education (occupation) gap is the difference between the score of students whose parents are highly educated (employed in socio-economically higher ranked occupations) and those whose parents are lower educated (have lower ranked occupations): positive values on these two gap estimates indicate that students with more privileged family backgrounds perform better. Further methodological details are detailed in Appendix I.

Figure 1 Gross and net (of print reading skills) digital reading gaps



Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. Lines are 95% confidence intervals. Poland and Hungary are omitted in the analysis of the migration gap because of too small numbers of children of immigrants in the sample.

The results of these regressions are presented in Figure 1, which shows *gross* group differences (grey bars) on digital reading and the *net* differences (black circles); the latter estimated after making "print" reading skills equal across groups. The vertical lines indicate the 95% confidence intervals around the estimates. For example, the first bar from the left in the top panel (gender gap) indicates that males underperform girls on the digital reading test in Austria. This difference amounts to roughly 25 points (approximately one fourth of a standard deviation) and is statistically significant, as the 95% confidence interval does not overlap with the zero line (which indicates a situation of equality of digital reading skills between groups). However, this gender gap vanishes once print reading skills are made equal across groups (black circle).

The overall picture provided by Figure 1 suggests that net differences are much smaller than gross ones (the circles are always closer to the "zero line"). This means that most of the differences observed in digital reading skills are due to group differences in basic (print) reading differences. However, there are important variations in the results depending on the different variables considered.

When considering gender gaps, males are clearly disadvantaged in all countries. However, this gap is reversed, boys performing better than girls, when holding pure reading skills constant across genders. This points to a key role played by digital skills in accounting for gender gaps in online reading skills. This pattern holds for nearly all countries; in some countries net gender gaps are virtually zero, while in no country do boys underperform girls once print reading skills are controlled for.

Turning now to migration background, children of immigrants underperform natives in the digital reading test, but once pure reading skills are held fixed, the gap vanishes. This result holds good for almost all countries. In some countries however a "migrant penalty" persists (Belgium, Denmark, Estonia and Norway), pointing to a "double" disadvantage of immigrants' children: not only in host-country language acquisition but also in digital skills' development. Israel appears as an outlier, as immigrants' children exhibit systematically higher scores than native students, highlighting the peculiar immigration patterns to this country compared with the European countries.

Finally, in all countries children of high-educated parents and parents with high occupational status show higher performance on the digital reading test relative to their counterparts with lower educated and less socio-economically advantaged parents. This pronounced social-background gap in digital reading is almost entirely explained by print reading skills. Overall, digital reading gaps between social groups are reduced by 80-90% when print reading skills are modelled, suggesting that social inequality is far more pronounced on basic traditional competences than on new digital competences. However, even if small, residual significant gaps persist in many countries (Austria, Denmark, France, Hungary, Israel, Norway, Poland, Portugal, Spain, Sweden, Slovenia, Slovakia), indicating that the "advantage" of children of more privileged social backgrounds is not always limited to "standard" competences but could also extend to digital ones.

3. The gaps in navigation skills

After establishing the extent to which gender, migrant and social backgrounds affect students' digital reading proficiency, this section investigates the role played by the same characteristics with respect to students' ability in navigating the web to answer the digital reading test questions.

Prior studies (OECD 2015a, 2015b) have already reported gender gaps in line to those shown and discussed in the previous section. These studies also suggested that the variance in digital reading due to students' social background could be partially due to social background variation

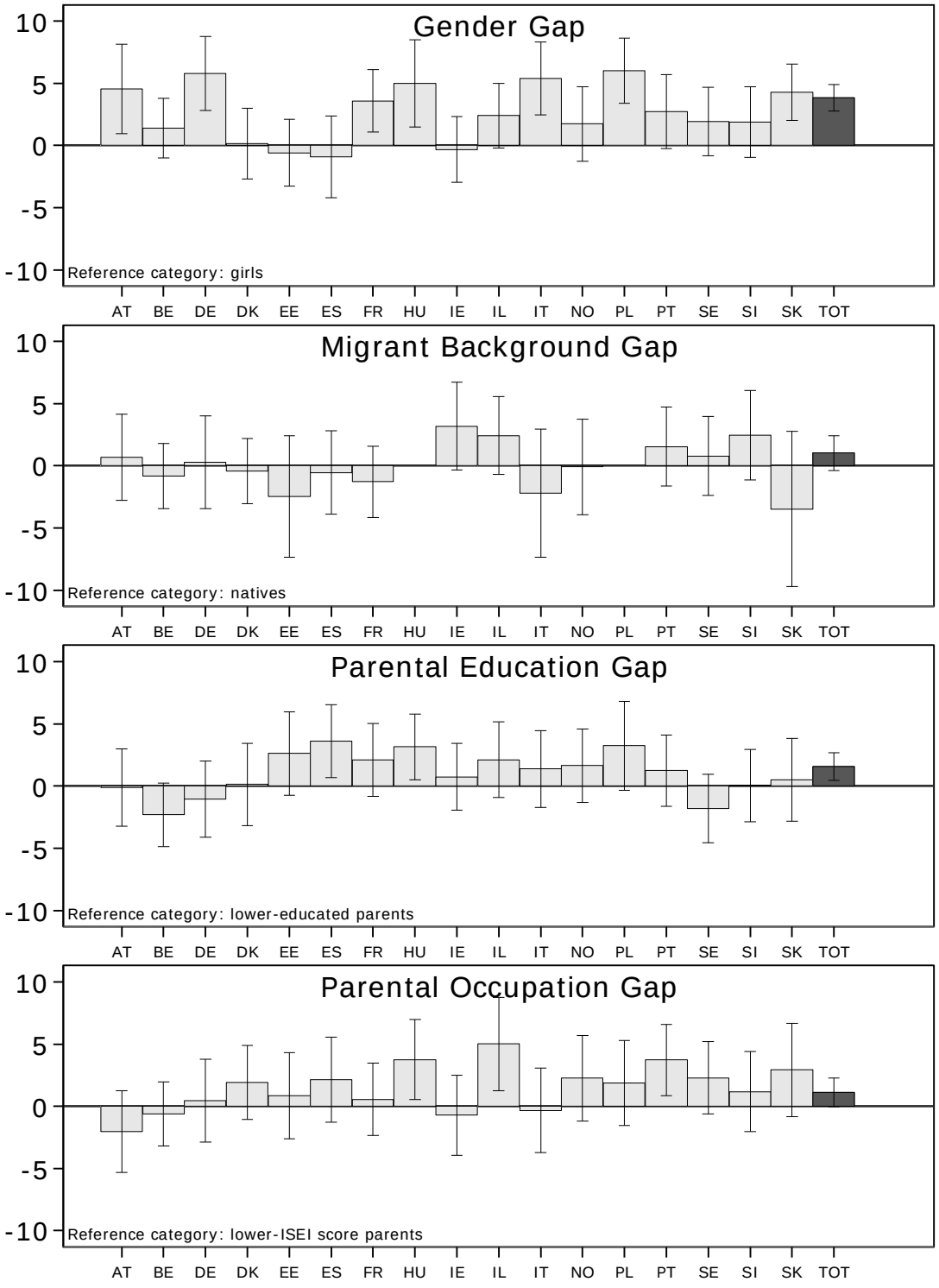
in digital skills (OECD 2015a). However, the link between these individual characteristics and navigation skills has not been closely studied yet.

Figures 2 and 3 show the results obtained with a series of OLS (Ordinary Least Squares) regressions aimed at capturing these gaps on the two indices (overall browsing activity index and targeted navigation index) net of print reading skills. Results show that boys clearly outperform girls on the overall browsing activity index, while they underperform girls on the targeted navigation index. This result suggests that males are more active and fast in taking action when answering digital reading tasks than girls (“trial and error approach”) while girls are more reflective and read more carefully before taking action (“think before clicking approach”). Boys’ higher activity on the web explains their advantage in the digital reading test (displayed in Figure 1). Results are fairly consistent across countries: in a number of countries, gender differences are not statistically significant, but "opposite" effects are never detected. In no country do girls show higher browsing activity or lower targeted navigation than boys.

When it comes to migration background, evidence is weaker, partly as a consequence of the small number of observations for students with an immigrant background. If any, a small advantage of children of immigrants is detected with respect to the targeted navigation index. But, overall, migrant/native differences in navigation behaviours are close to zero in nearly all countries. Thus, it can be concluded that, once print reading skills are controlled for, children of immigrants display the same navigation skills as natives.

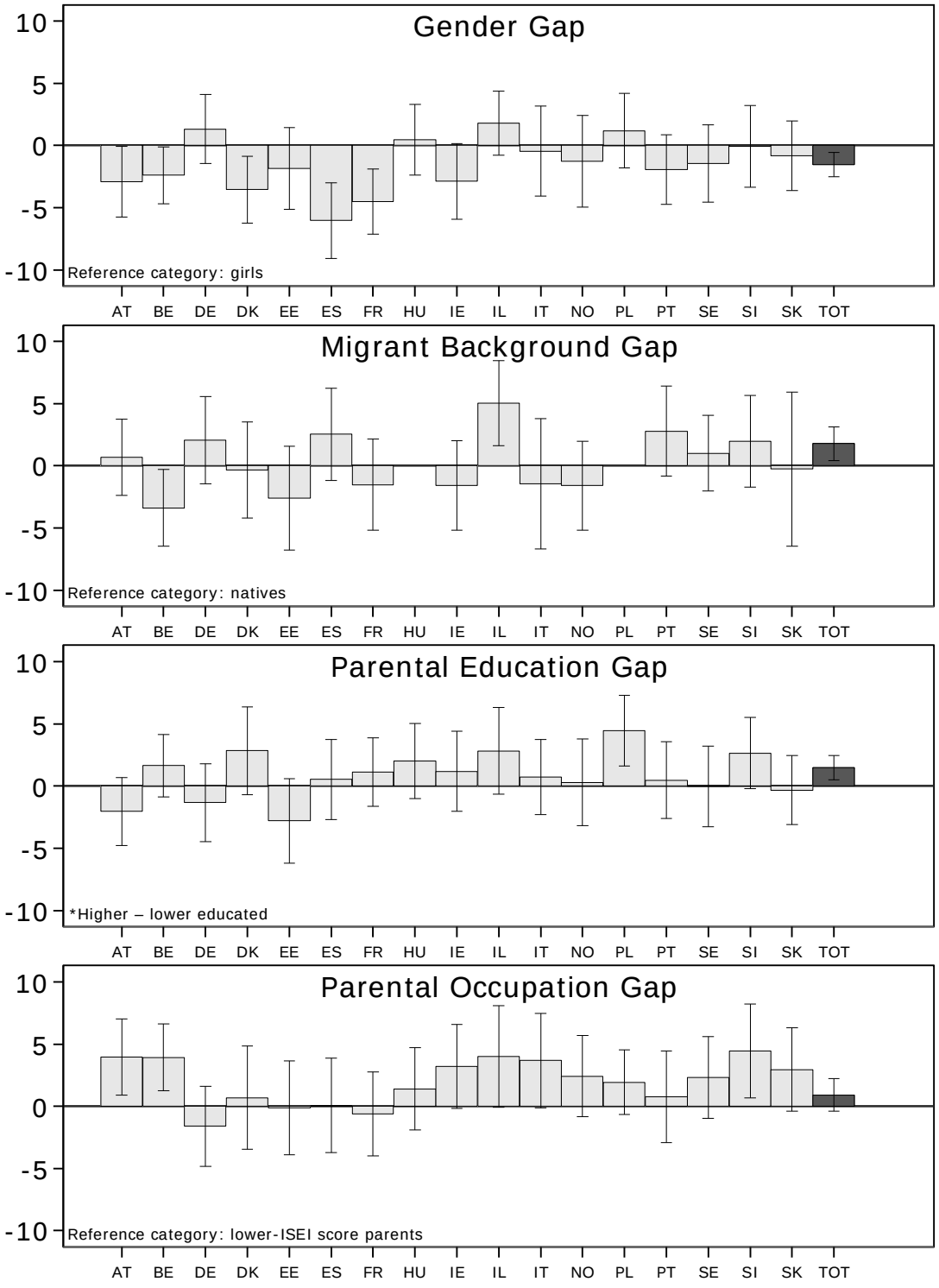
With respect to the role played by social background, Figures 2 and 3 report substantially small positive effects of parental education and parental occupation. In many countries, differences between groups are not significantly different from zero, but when significant, they point to a positive association between parental education and parental occupation on the two indices of navigation skills. Statistically significant coefficients of the two social origins indicators are detected in Spain, Hungary, Israel and Portugal, for the overall browsing activity index, and Austria, Belgium, Poland and Slovenia, for the targeted navigation index. In none of the considered countries do students from lower social backgrounds outperform their counterparts from more privileged backgrounds on the digital skills indices considered. Hence, net of print reading skills, students from poorer social backgrounds show a small penalty in the development of navigation skills.

Figure 2 Overall Browsing Activity Gaps, net of print reading skills



Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data and CBA log files.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. Lines are 95% confidence intervals. All models control for students' print reading skills. Poland and Hungary are omitted in the analysis of the migration gap because of too small numbers of children of immigrants in the sample.

Figure 3 Targeted Navigation Gaps, net of print reading skills



Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data and CBA log files.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. Lines are 95% confidence intervals. All models control for students' print reading skills. Poland and Hungary are omitted in the analysis of the migration gap because of too small numbers of children of immigrants in the sample.

The digital skills gaps presented in Figures 2 and 3 could be partially related to group differences with respect to students' familiarity with ICTs, which could arise as a consequence of different ages of ICT first exposure, variation in home availability of ICTs, as well as different patterns and intensity of use of ICTs and the internet. To shed light upon these aspects, Table 1 shows a comparison of several indicators across genders, migration and social backgrounds.

Table 1 ICT and internet use by gender, migration background and social origins

	Used ICTs before the age of 9 [b] (%)	ICT availability at home [a, c]	ICT Use at Home for School-related tasks [a]	Internet use for gaming [a]	Internet use for news [a]	Internet use for social networks [a]	Limitations of the Computer as a Tool for School Learning [a]
Gender							
Females	**.74**	**-.04**	**.02**	**-.54**	**-.15**	-.04	**-.13**
Males	**.81**	**.17**	**-.03**	**.41**	**.02**	-.02	**<-.01**
Migration background							
Natives	**.78**	.06	<.01	**-.04**	-.05	-.03	**-.08**
Non natives	**.74**	.10	-.02	**-.11**	-.11	-.01	**.01**
Parental education							
Up to secondary	**.74**	**-.06**	**-.05**	-.05	**-.10**	-.03	**-.02**
Tertiary	**.82**	**.23**	**.07**	-.08	**-.01**	-.03	**-.12**
Parental occupation							
Low ISEI score	**.76**	**.04**	**-.02**	**-.04**	**-.09**	**<-.01**	**-.03**
High ISEI score	**.84**	**.19**	**.08**	**-.11**	**.05**	**-.09**	**-.18**

Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data.

Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. Statistically significant differences in bold.

[a] Average value of an Index with mean 0 and standard deviation 1 (at the OECD level).

[b] The age of nine is chosen for it is a critical period in childhood, when the majority of children make the transition from “learning to read” to “reading to learn”.

[c] The index measures households’ possession of different objects such as a desktop or portable computer, an internet connection, a printer, a cell phone, etc. In France this information was not collected.

In support of the interpretation of the results presented so far, boys declare that they have been exposed earlier than girls to ICTs: 81% of boys say they first used the computer or the internet before the age of 9, while only 74% of girls do so. Also, males state that they have more ICT resources at home, use the internet more, use ICTs for doing homework less and much more for gaming. The latter result could explain their higher browsing activity when taking the PISA digital reading tests. Interestingly, boys also display more negative attitudes towards the use of ICTs in their education.

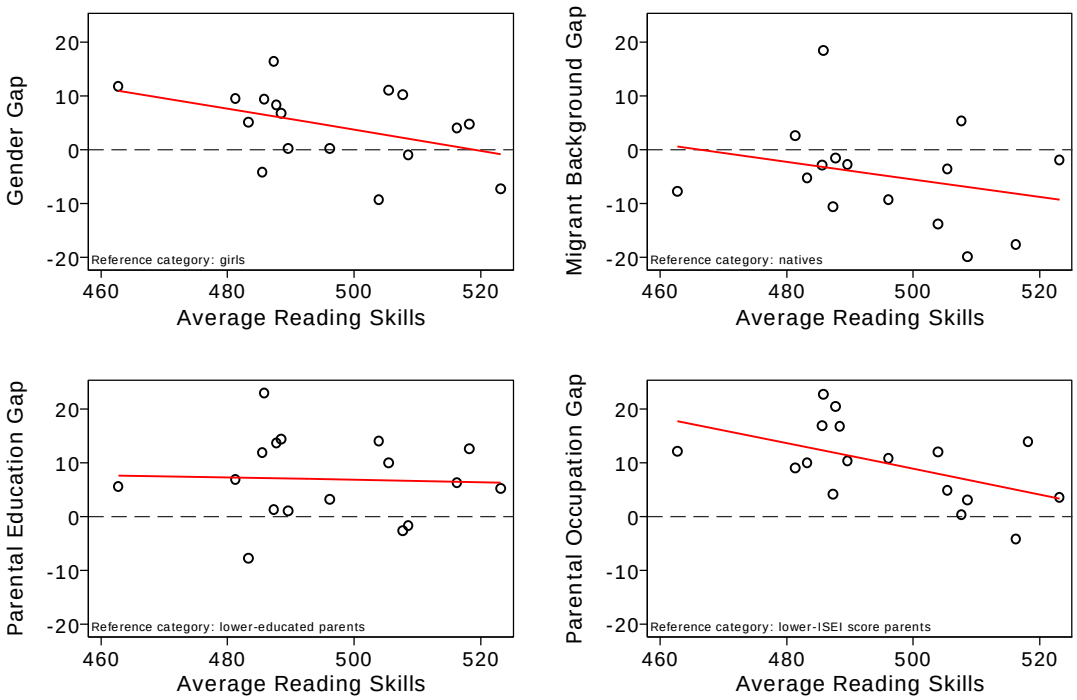
Overall weaker differences exist between immigrants' children and native students, although the former are exposed later to ICTs; use less the internet for gaming and have more negative attitudes with respect to the role of ICTs in education.

When looking at social background, a clear and systematic divide comes up, with students from parents with higher education and occupational status stating that they have been exposed earlier to ICTs and live in households that are better technologically equipped. Also, they report using ICTs and the internet more for doing homework and keeping up to date with news and less for gaming. Furthermore, they show more positive attitudes towards the use of ICT in education.

4. The role of institutional and school factors

Sections 2 and 3 have documented the existence of gender, migration- and social-background differences in digital reading and navigation skills. These gaps show some degree of variability across the countries analysed. Hence, the role played by institutional features and school characteristics as mediating factors are certainly worth studying. This is accomplished through a set of descriptive analyses that are at the core of the present section.

Figure 4a Relationship between country average print reading performance and "net" digital reading gaps



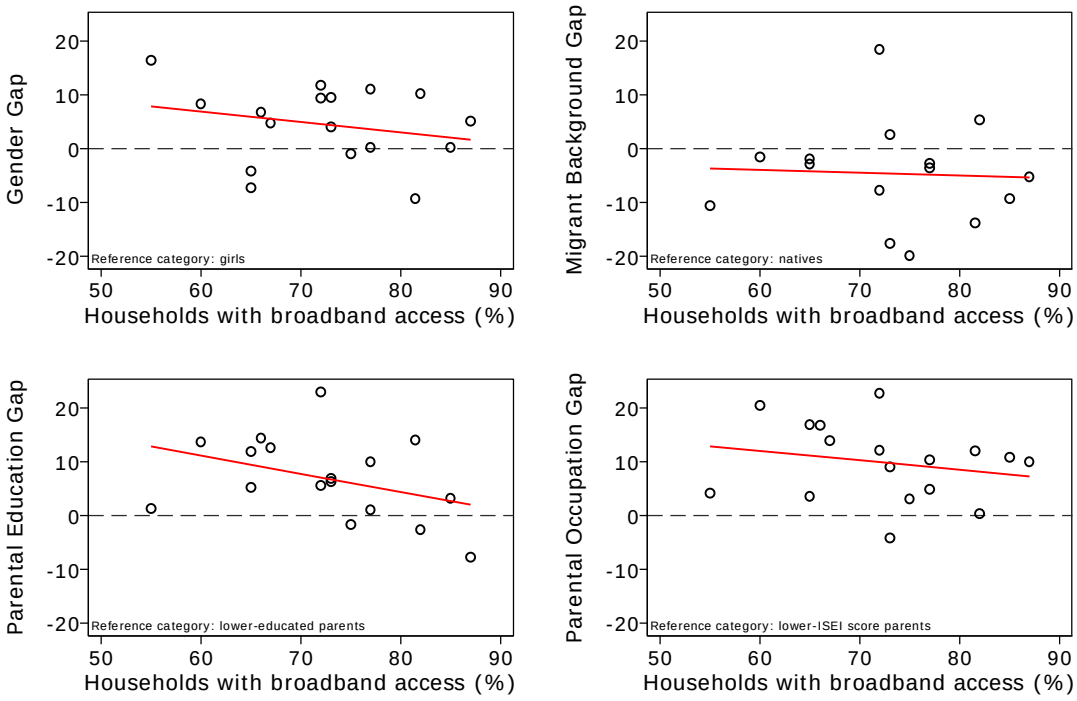
Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. The horizontal dashed line represents a situation of equality between groups. Poland and Hungary are omitted in the analysis of the migration gap because of too small numbers of children of immigrants in the sample.

In the first place, we ask if the estimated net gaps in digital reading are related to countries' overall educational performance, here measured by the national average print reading scores. To put it differently, we ask if better-performing systems are also more "equal" than worse-performing ones when it comes to students' digital skills development. Figure 4a shows these relationships graphically for each of the four sources of inequality considered. For example, the top-left panel shows that boys' advantage over girls progressively shrinks, and becomes virtually zero, as the quality of the system improves. Hence, at least with regard to the gender gap, better-performing countries in terms of overall performance are also more equal. A similar pattern is observable for parental occupation gaps, suggesting that better-performing systems are more equitable also from a socio-economic point of view. However, the parental education gap happens to be substantially unrelated with the country overall educational performance, this suggesting that the relationship between quality and social equity in a given education system is indeed a complex one and requires further investigation, which is far beyond the scope of this report. Furthermore, children of immigrants (top-right panel) show larger disadvantages relative to natives in higher-quality systems as compared to lower-quality ones. This latter result could be related to different mechanisms of immigrant selectivity in the receiving countries but it shall be born in mind that migration background gaps estimates are particularly affected by uncertainty due to the small numbers of observations in the PISA

samples. Hence, overall the analysis does not provide conclusive results on the nexus between "quality" and "equality" of the education systems, and more research is need.

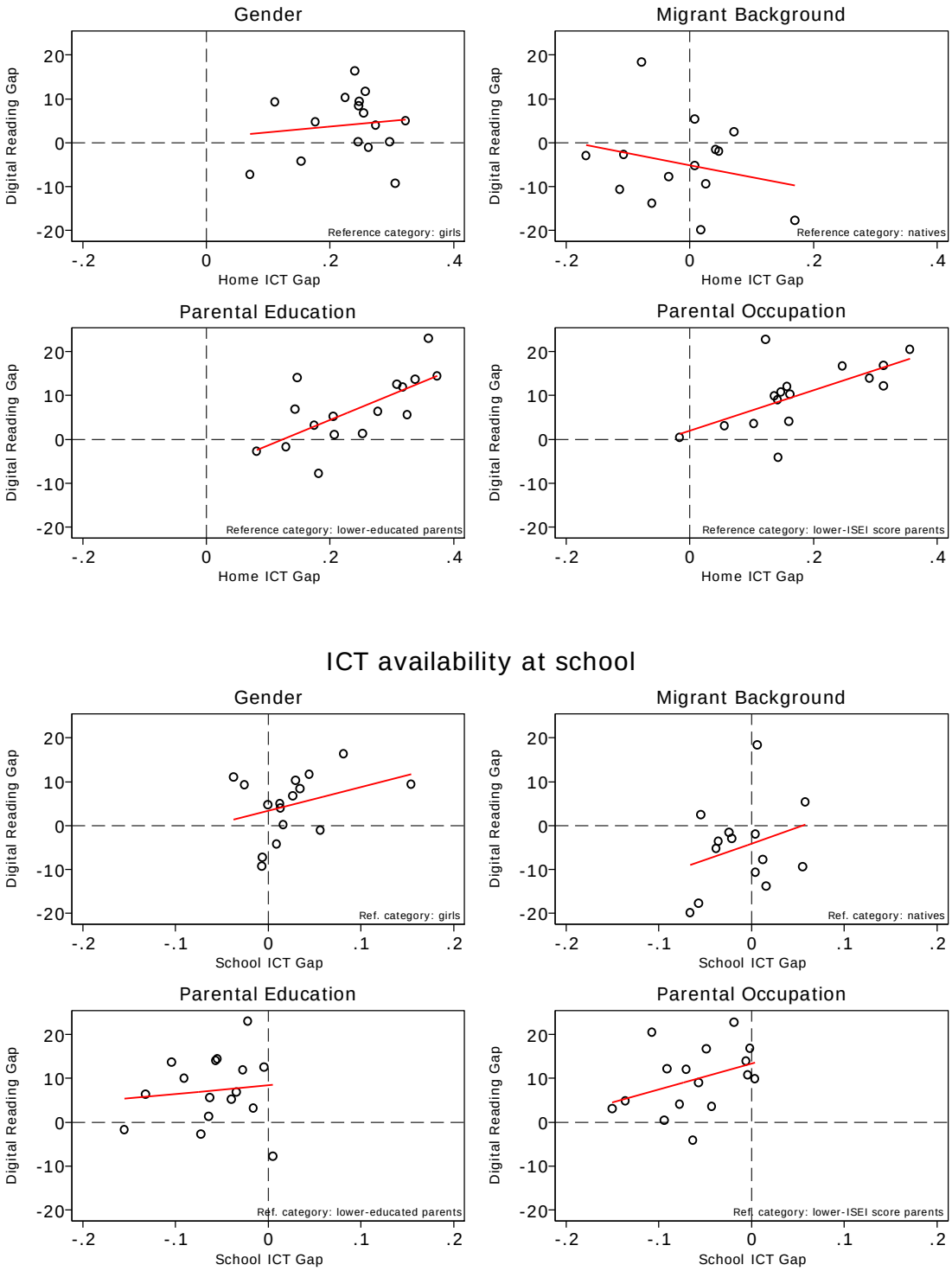
The second system-level dimension that we explore is related to countries' ICT infrastructure levels. The question is whether better technologically equipped countries facilitate a more equal development of ICT skills among the young population. Figure 4b shows that there is a weak but negative relationship between the share of households with broadband access and the net digital reading gaps: the more ICT-equipped a country, the smaller the digital reading gaps across genders and social backgrounds. The migration background gaps, however, do not seem to be affected by the level of technology permeation in the country, signalling the possible existence of differentiated access to ICTs depending on individuals' immigrant background.

Figure 4b Relationship between broadband diffusion in the country and "net" digital reading gaps



Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data and OECD data.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. The horizontal dashed line represents a situation of equality between groups. Poland and Hungary are omitted in the analysis of the migration gap because of too small numbers of children of immigrants in the sample.

Figure 4c Relationship between gaps in ICT accessibility and "net" digital reading gaps



Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. The dashed lines represent a situation of equality between groups. In France, information on ICT availability at home was not collected. Poland and Hungary are omitted in the analysis of the migration gap because of too small numbers of children of immigrants in the sample.

In Figure 4c we look at whether inequalities in certain "inputs" are associated with digital reading gaps. As measures of inputs we consider students' access to ICTs at home (we use here the same index used in Table 1) and at school (here, we rely on the PISA provided indicator of PC-student ratio at school). Note that the latter can be seen as measures of the so-called

"first digital divide". Overall, Figure 4c confirms the expectation that larger gaps in inputs (i.e., in the availability of ICTs) lead to larger gaps in outcomes (i.e., in the net digital reading gaps). Interestingly, this pattern is clear when considering home gaps but less evident when considering school gaps, suggesting the more prominent role of family environment as compared to the school one. In the latter case, indeed, the ICT access gaps across groups are very small (as also found in OECD, 2015a) and in many cases not significantly different from zero. Hence, the relationships with digital reading gaps are weaker. Moreover, when considering migrant background gaps, an apparently contradictory result is found, as the digital reading gaps seem to be smaller in countries where gaps in ICT access at school are larger. It should be noted though that the range of variation in the ICT school gaps between immigrants and natives is relatively small and this adds further uncertainty to the estimates, already affected by the small sample sizes of immigrants' children. Hence, once again, the results for the immigrant background gaps should be taken as provisional and be the object of further in-depth studies.

In the second part of this section, attention is shifted to the role played by schools. In order to establish the extent to which schools influence students' navigation skills, over and beyond individual variability, a statistical analysis of navigation skills variance is performed. More precisely, the variance in the overall browsing activity index and in the targeted navigation index is partitioned into an individual and into a school component, this allowing to calculate the so called Intra Class Correlation, which in our case is the proportion of school-level variance on the total variance. The calculated Intra Class Correlation indicates that schools account for only 3-5% of the variance in the two indices. It should be noted that the estimate of within-school variance might be inflated by measurement error (which increases at the individual level and is reduced when considering school averages). The existence of individual-level measurement error would lead to an underestimation of the actual role played by schools. However, when replicating the analysis on traditional competences (reading, mathematics, and science), the Intra Class Correlation is substantially and systematically higher (around 13-17%). Hence, individual factors clearly play the major role in students' development of digital skills, while the role of schools is substantially small—and definitely smaller than in more 'traditional' domains, such as reading, mathematics and science. This result could be explained by the fact that school and classroom activities are much more dedicated to traditional competences, leaving little time for digital skills instruction.

Finally, the role played by school factors and educational institutional arrangements in students' development of navigation skills is jointly investigated by the means of a series of ordinary least squares (OLS) regression models estimated on the pooled set of countries (Table 2). The first model (M1) includes students' characteristics (such as immigrant background, sex, parental education and occupation) and educational performance (i.e., score in print reading and grade attended relative to the country modal grade attended by same-aged students). Model 2 (M2) adds indicators of school quality (such as student-teacher ratio and school average print reading score) and indicators of schools' availability and use of ICTs (such as the PC-student ratio in the school and an index measuring the intensity to which internet is used in schoolwork, as reported by school principals). To account for factors that vary across countries and might affect the results, the model also includes country fixed effects. Finally, Model 3 (M3) investigates the role of some characteristics of the education systems largely employed in the comparative education literature (Allmendinger, 1989) such as the degree of centralisation (centrally governed education systems vs systems with high autonomy at the regional/local levels), curricula standardisation (systems regulating in great details the school curricula vs system that allow a greater school autonomy in curricula definition), and finally horizontal stratification (systems that track 15-year-old students into different educational programmes *vs* comprehensive systems).

Table 2 The role played by school and institutional factors in students' development of navigation skills (N=22,254)

	Overall browsing activity			Targeted navigation		
	M1	M2	M3	M1	M2	M3
Non native (ref. native)	**2.19**	0.97	1.35	**1.99**	0.54	1.38
Male (ref. female)	**3.41**	**3.28**	**3.20**	**-1.54**	**-1.83**	**-1.86**
High-educated parents (ref. low/medium)	**1.41**	0.62	0.98	0.72	-0.23	0.38
High-ISEI parents (ref. Low)	-0.23	-0.63	-0.66	1.02	0.50	0.55
Print reading score	**0.12**	**0.11**	**0.11**	**0.12**	**0.10**	**0.10**
Grade (relative to country mode)	**1.29**	**2.26**	0.72	**1.48**	**1.36**	0.90
Student-teacher ratio		0.13	0.10		-0.03	-0.02
PC-student ratio		0.13	0.15		0.49	0.54
Index of internet use in school		0.30	**1.44**		-0.13	0.20
School average print reading score		**0.03**	**0.03**		**0.05**	**0.05**
Low Centralization (ref. high)			**-2.35**			-1.11
Low Curricula Standardization (ref. high)			0.14			-0.27
Horizontal stratification (ref. Comprehensive)			**7.19**			**4.33**
Constant	-17.08	-24.24	-30.44	-12.29	-22.96	-27.15
Country Fixed Effects	No	Yes	No	No	Yes	No
R-squared	0.20	0.25	0.22	0.21	0.23	0.22

Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. Statistically significant coefficients in bold.

Keeping in mind that the results produced with this analysis cannot be interpreted causally, Tables 2 suggests that schools and education systems play a small role in students' development of digital skills. Models' goodness of fit (R-squared) shows little improvement when school and education system variables are included in the models. Measures of the schools' availability and use of ICTs (i.e., PC-student ratio and internet use in school) do not seem to be relevant for students' development of navigation skills net of students' characteristics. However, the "quality" of the school attended (measured with the school's average print reading score) is positively and significantly correlated with both indices. Hence, students attending good quality schools (i.e., schools performing well on the PISA reading test) are more likely to exhibit better digital skills.

Overall, also the features of education systems' play a small role. The degree of centralisation of the education systems is never found to be significantly associated with students' digital skills. Systems characterised by low degrees of curricula standardisation seem to favour students' quantity of navigation without, however, affecting the quality of their navigation. Finally, students enrolled in systems characterised by some horizontal stratification tend to develop more and higher-quality navigation skills as compared to students in comprehensive systems. The interpretation of this result could be that a certain degree of between-school differentiation facilitates a better matching between students' skills and aptitudes and schools' curricula, with positive consequences in terms of performances.

Finally, Table 2 shows that, net of all school and institutional factors, only gender gaps persist significantly, confirming boys' higher navigation activity and girls' more focused navigation behaviour. In turn, immigrant- and social background gaps are fully accounted for by individual and school characteristics.

5. Conclusions

This report investigates the "second digital divide" among 15-year-old students in 17 countries (15 EU countries plus Israel and Norway) and the individual and contextual factors influencing it. The empirical analyses point to the existence of pronounced gender, migration-background and social-background gaps in digital reading. This result comes as no big surprise, as these ascriptive characteristics are widely known to affect students' learning and competences (see for example OECD, 2010). The novel contribution of this study lies in the finding that the largest part of these digital reading gaps is due to differences in print reading skills. Hence, inequality in digital reading competences is strongly attributable to students' development of standard competences and not to digital ones.

This result might contribute to a comprehensive reflection on the second digital divide within the broader debate on educational inequality. The emerging question is whether the widespread use of technology in teaching and the increased number of competence domains that require an intense use of ICTs amplify or reduce educational inequalities. Answering such a question is beyond the scope of this report, but the findings presented here seem to suggest that inequality might be larger in "traditional/standard" competences than in "new/digital" ones. This seems not only to be confined to the reading domain, but to extend to all competences domains investigated by PISA (see Table 3). Indeed, disparities tend to be larger in traditional competences (paper tests) and less relevant in digital ones (computer tests), especially when considering immigrant background and parental occupation. The weaker influence exerted by family backgrounds on digital skills may be tentatively explained by the consideration that today's 15-year-olds are "digital natives" and are likely to possess more digital skills than their parents do. This "generational gap" in digital skills might reduce parents' role in directly affecting their children's digital skills development. Further research is of course needed to test this hypothesis as well as to shed light on the mechanisms underlying the transmission of these skills.

Keeping this overall picture in mind, the empirical findings indicate that some significant gaps in digital reading persist across groups even net of print reading skills. The case of gender differences is remarkable. Boys underperform girls on the digital reading test but, when print reading skills are equalised across groups, their "disadvantage" turns into an "advantage", suggesting that they are more proficient than girls with computers and ICTs. Boys do indeed show significantly higher navigation activity levels than girls, but when considering the quality of navigation, they fall behind girls. The latter result points to the possible existence of gendered approaches to ICTs and the internet, with boys being, on average, more "technically" capable to interact with computers but at the same time being also less focused when navigating; whereas girls appear to be more reflective. In other words, boys seem to be more prone to a "trial and error" approach while girls are more keen to a "think, then click" one. These gaps may arise from the existence of gender differences in ICT familiarity, which this report has documented on several factors like age of first exposure to ICT, frequency and patterns of use of computers and the internet, as well as attitudes towards the use of ICT in education.

Table 3 Comparison of the gap estimates on paper and computer-based PISA tests

Gap	Paper-based tests			Computer-based tests		
	Reading	Mathematics	Science	Digital Reading	Computer Mathematics	Problem Solving
Gender (Boys – Girls)	**-41.9**	**11.4**	-0.3	**-25.3**	**14.5**	**8.3**

Migrant background (Non-natives - natives)	**-35.3**	**-40.7**	**-44.1**	**-23.6**	**-29.6**	**-28.5**
Parental education (Higher – lower educated)	**35.7**	**38.4**	**36.5**	**36.7**	**36.0**	**34.2**
Parental occupation (Higher – lower ISEI score)	**59.8**	**60.8**	**58.5**	**55.8**	**51.2**	**50.3**

Source: FBK-IRVAPP elaborations based on PISA CBA 2012 data.
Note: Estimates are obtained using the five plausible values, the final student weights and the 80 replicate weights. Statistically significant coefficients in bold.

When considering social background gaps in digital reading, these are strongly attributable to print reading competences. However, in some countries there is evidence of a small "advantage" of children of more privileged social backgrounds that is not limited to "standard" competences but also includes digital ones. Moreover, children of more affluent or more educated families also show higher navigation skills. Hence, digital skills might represent a further area of concern for educational inequality, which might cumulate on traditional aspects. Digital reading gaps between natives and children of immigrants are close to zero. However, the fact that migrant/native gaps are smaller when reading tests are digitally administered rather than on paper leads to the hypothesis that children of immigrants deploy their navigation skills to compensate, at least partially, for their lower mastery of the host country language. More studies are needed to shed further light on the factors that produce or alleviate the reported digital reading gaps across genders, migration- and social backgrounds.

Finally, the results seem to indicate that the digital gaps are negatively correlated with some characteristics of national school systems, such as their overall quality, and the spread of ICT infrastructures in the countries. In other words, the report suggests that better-performing education systems and more technologically developed countries provide more favourable contexts for an equal development of digital skills among the young population. However, it shall be reminded that the analyses are based on correlations and are affected by some degree of statistical uncertainty. Hence, the presented results should not be taken as conclusive and more studies are needed to identify clear policy implications. When looking at other drivers of digital skills, such as students' access to ICTs at home and at school, there is moderate evidence that closing "accessibility gaps" might turn into a reduction of the gaps in digital skills. It is interesting to stress that the family contributes to this reduction more than schools, also because social divides in ICT access are larger at home than at school (OECD, 2015a). This result could be explained considering that, even though ICTs are increasingly widespread in the classrooms, most school activities still focus on the development of traditional competences. To conclude, further research needs to be carried out in order to ascertain what types of education policies and practices can reduce educational inequality, ICT competences included. Such research would be particularly welcome in the light of the increased intensity and breadth of use of ICTs both in schools and in society at large.

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Annex I Methodological annex

The PISA 2012 files used in the analysis are listed in Table A1. The files were merged using student and school IDs.

Table A1 Data overview [a]

File	Contents
Student	• *Paper-based assessment (PBA):* o mathematics o reading o science [b] • *Computer-based assessment scores (CBA)*: o problem solving (PS) o mathematics (CBAM) o digital reading (DRA) • *Student questionnaire* (background, attitudes, behaviours, several items on ICT access and use, both at home and at school)
School	*Principals' questionnaire* (school organization, policies and practices, resources, curriculum & assessment, student/teacher body, school climate)
CBA Log files	*Students' navigation behaviours when taking the CBA-DRA test*. The CBA system collected behavioural data such as time spent on task, sequence of pages visited, and use of stimulus elements such as drop down menus. In some cases, such behavioural data contributed to scoring.

[a] Parent questionnaires cannot be used as not delivered in all countries. Information on families is retrieved from student questionnaires.
[b] Some countries also administered a financial literacy test.

PISA 2012 was administered differently in the participating countries (Table A2). While all countries administered the paper-based tests (PBA), only a subset of countries (44) administered the computer-based assessments (CBA), and among the latter only some countries (32) administered the digital reading module of the CBA. Countries implementing any part of the assessment via computer administered either the assessment of problem solving only, or, assessments of all three tests (PS, CBAM, and DRA). They could not choose to administer CBA while opting out of the assessment of problem solving. Moreover, in the third group of countries, not all students took all the three CBA tests, but these were randomly administered to different subsamples of students (see OECD-PISA 2012 technical manual for further details).

Table A2 Different combination of PBA and CBA tests in PISA 2012

Assessment tests	Countries
1) PBA	All
2) PBA + CBA (PS)	44
3) PBA + CBA (CBAM+DRA+PS)	32

This differential implementation design of the survey has some practical implication for our research, as for some of the countries intended to be included in the analyses, the relevant data are not available. More precisely, seven countries (Luxembourg, Latvia, Lithuania, Romania, Cyprus, Greece, and Malta) did not take part to the Pisa CBA tests; and six other countries (Bulgaria, Czech Republic, Finland, Great Britain, Croatia, and the Netherlands)

administered only the problem-solving module. As a consequence, only 17 countries (Austria, Belgium, Germany, Denmark, Spain, Estonia, France, Hungary, Ireland, Israel, Italy, Norway, Poland, Portugal, Slovakia, Slovenia, Sweden) are included in the analysis on the relationship between navigation skills and student competences. Table A3 shows the size of the sample used in the analyses. The second column (CBA) shows the number of students who were administered a CBA test, while the third column (Log files) indicates the number of students for whom the information on navigation skills is available—i.e. the students who took the DRA test. The analyses presented in this report are based on the "log files" sample. Missing values on some contextual variables, however, forced us to drop some observations from the analyses.

Table A3 Sample size in the CBA database and in the log files

Country	Code	CBA	Log files
Austria	AT	4,755	1,308
Belgium	BE	8,597	2,169
Germany	DE	5,001	1,356
Denmark	DK	7,481	1,917
Spain	ES	10,175	2,737
Estonia	EE	4,779	1,376
France	FR	4,613	1,343
Hungary	HU	4,810	1,321
Ireland	IE	5,016	1,182
Israel	IL	5,055	1,144
Italy	IT	5,495	1,376
Norway	NO	4,686	1,234
Poland	PL	4,607	1,275
Portugal	PL	5,722	1,455
Slovakia	SK	4,678	1,466
Slovenia	SI	5,911	2,063
Sweden	SE	4,736	1,273
Total		96,117	25,995

Navigation behaviours are measured with two indices derived from the CBA log files created while students were answering the CBA-DRA tasks. Particularly, the log files contain a measure of the "length of navigation sequences" (i.e., number of movements/steps between different pages). Also, they provide "qualitative" information of each step: task-relevant step (from and to a relevant page); misstep (from a relevant to a non-relevant page); correction (from a non-relevant to a relevant page); task-irrelevant step (from and to a non-relevant page). This information was used to construct the two indices used in the analysis:

a) *index of overall browsing activity*: given by the total number of steps;
b) *index of targeted navigation*: given by the total number of task-relevant steps subtracted by missteps and task-irrelevant steps.

The values of the two indices range between 0 and 100—with 0 indicating no (targeted) activity and 100 indicating maximum (or, maximally targeted) activity—and reflect the percentile score given by the rank of the student among all students who were administered the same digital reading questions.

As for the main independent variables employed in the analyses, they were coded as follows. Gender takes value 1 for males and 0 for females. Migrant background takes value 1 for those students whose both parents were born abroad and 0 otherwise. Parental education takes value 1 for students who have at least one parent with ISCED5 (tertiary) education and 0 otherwise. Parental social position, that is to say students' social origins, is measured by means of ISEI (International Socio-Economic Index of Occupational Status) scores. ISEI is a

standardised measure of the level of social prestige associated to every occupation listed in the 1988 version of the International Standard Classification of Occupation (ISCO88). In the analyses, the ISEI index is recoded as a dummy variable taking value 1 for students with one parent scored in the ISEI index equal or above the 75th percentile and 0 for their counterparts with both parents' ISEI score below the 75th percentile. The percentile distribution is computed country by country.