TV Digital Transition in Italy and the Impact on Pupils' Academic Performance*

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February 2025

Abstract

This paper studies the impact of television on student achievement in Italy, utilizing the staggered rollout of digital television across Italian provinces to isolate television's influence. Using data from national educational assessments (INVALSI) collected in four grades from 2009 to 2012, we uncover a negative effect of television on school performance by applying difference-in-differences techniques. We observe a positive correlation between TV viewing and test scores for a subset of the survey. Still, the negative impact is partly confirmed when instrumenting hours of view with the availability of digital channels. We also find significant heterogeneity: foreign-born pupils benefit from the greater availability of TV channels, while children with graduate parents experience less significant achievement losses.

Keywords: school performance, digital television switchover.
JEL Codes: I2, I24, O33.

*We would like to thank the participants of the seminars in Alghero (IBEO workshop), Milan and Irvap-FBK for their comments. We would also like to thank Enrico Rettore and Marco Gambaro for their helpful comments. All remaining errors are ours.

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1 Introduction

Television is one of the most pervasive aspects of Italians' lives. The average Italian adult watches about three hours of television per day. For Italian children, television viewing represents an important portion of waking hours, following school attendance (see ISTAT (2022)). Recent research, such as DellaVigna and La Ferrara (2015), reveals that television viewing can profoundly influence various aspects of individuals' lives, including consumption behaviours, educational outcomes, political involvement, perceptions of crime, and even marital dynamics. Given the significant amount of time that most individuals in Italy devote to watching television, it becomes crucial to investigate its impact on society, including human capital accumulation and academic achievement. This paper studies the impact of television on student performance using the digital television switchover, focusing on understanding the underlying mechanisms. Until 2007, which marked the year preceding the transition from analogic to digital TV signal transmission, Italy had a concentrated television market. Just seven national channels were accessible to viewers through analogic signals. The Italian public broadcasting system (Rai) consisted of three media (Rai1, Rai2, and Rai3), whereas three channels (Rete4, Canale5, and Italia1) belonged to a private company, Mediaset, owned by the Berlusconi family. A seventh small channel, LA7, was owned by a private organisation. While television played an essential role in improving adult literacy in the 1960s, as evidenced by Malisan (2025),[1] the expansion of television offerings following the digital switchover has introduced new dynamics, with potential implications for society as a whole, and particularly for students' academic performance. Between 2008 and 2012, Italy gradually transitioned from analogue to digital TV transmission. The transition from analog to digital television broadcasting occurred on a geographical basis, with designated "switch-off" dates for each province within each region. Following these dates, television channels were exclusively transmitted in digital format. Around the digital switchover, national free TV channels increased from 7 to almost 50. This sudden increase in supply coincided with a significant decline in the viewership shares of the six main traditional analogue channels (Rai and Mediaset), dropping from 82% in June 2008 to 60% in June 2012, in favour of the new digital channels.[2]

This paper explores the transition from analogue to digital television signals to examine the impact of media access on school performance. To this scope, we employ the National Program for the Assessment of Schools run by INVALSI, the Italian government agency that annually measures student achievements in literacy and numeracy. We use the test results from four surveys conducted between 2009 and 2012 to study the relationship between television access and test scores among young Italian pupils. Given data availability, we can analyse four levels of education: students attending 2^{nd} and 5^{th} grades (primary school) and 6^{th} and 8^{th} grades (junior high). For a sub-sample for which information is available (grades 5 and 6, three waves), we also explore the impact of viewing hours on achievements.

While our paper is the first to utilize Italy's digital transition to examine the influence of tele-

[1] Malisan (2025) examines the role of televised educational programs in improving adult literacy rates in 1960s Italy, showing that greater TV signal exposure led to significant improvements in literacy, particularly among men.

[2] http://www.auditel.it/

vision on educational performance, several other studies have used this transition to analyse different subjects. Barone et al. (2015) and Durante et al. (2019) investigate the causal impact of media on electoral outcomes. Mastrorocco and Minale (2018) explore the effect of media coverage of crime episodes on crime perception, and Principe and Carrieri (2020) study the impact of higher media exposure on the size and composition of households' food baskets.

The literature regarding the impact of television on academic achievement offers a diverse range of findings. Earlier studies revealed a negative correlation between television viewing time and academic performance.[3] On the contrary, Huang and Lee (2010) present a nuanced finding: their study investigates the influence of television viewing during ages 6-7 and 8-9 on school performance, measured by math and reading scores at ages 8-9. Using data from the NLSY79 longitudinal sample, they identify a negative correlation between television viewing and math scores. They also show that watching no more than two hours of TV daily positively affects reading scores, but this effect turns negative beyond that threshold. Furthermore, research investigating causal relationships has yielded varied findings. Kearney and Levine (2019) exploit the variation in the introduction of the Sesame Street TV program in the United States in 1969, alongside census data, to show that exposure to educational TV content during preschool years positively affects later academic achievement. Gentzkow and Shapiro (2008) utilises the introduction of television in the US in the 1940s and 1950s to provide historical causal evidence that exposure to television in preschool positively impacts education for teens. However, Hernæs et al. (2019), utilizing the variety in cable television in Norway from the 1980s to the early 2000s, show that childhood exposure to television entertainment diminishes academic attainment in early adulthood, particularly among students with highly educated parents.

The closest paper to ours is Nieto Castro (2025), which exploits the exogenous variation in the transition date from analogue to digital television signal in the UK. Using a large administrative dataset of students in state-funded education in England, he shows that the switchover increases pupil test scores, and economically disadvantaged students and low achievers drive the effect. Our paper, alongside the work of Nieto Castro (2025), investigates the influence of television on academic performance, providing direct insights into the underlying mechanisms. While Nieto Castro (2025)'s study focuses on the digital transition in England and encompasses data from the entire population of 11-year-old students attending state-funded schools, our research extends to the entirety of Italian students across four educational levels. Utilizing the exogenous variation in the transition date from analog to digital television signals across different regions of Italy, we analyse the influence of television on pupil academic performance and explore potential mechanisms. To this scope, we initially focus on a difference-in-differences strategy, the results consistently indicating a detrimental effect of television on academic performance across all grades with the partial exception of 6^{th} grade results in numeracy. However, when exploring the heterogeneity of this effect, we find that increasing the channel supply benefits foreign-born students, especially in literacy test scores. We then explore the potential channels of this evidence, using additional information only available from students in 5^{th} and 6^{th} grades. The rise of Digital Terrestrial Television (DTT) may impact children's viewing habits,

[3] See, for example, Keith et al. (1986), Hancox et al. (2005) and Zimmerman and Christakis (2005).

potentially affecting academic achievement. While DTT may offer more educational content, increased screen time could displace study time. We employ regression analysis to assess the association between television exposure and student performance on achievement tests. OLS analysis yields a positive correlation, suggesting increased television viewing time is associated with higher test scores. However, concerns regarding potential endogeneity suggest employing instrumental variables (IV) methodology to address this potential bias. We utilise the transition to digital and/or proximity to digital terrestrial television implementation infrastructure as instruments to isolate the causal effect of television viewing on test scores. The IV analysis confirms a negative impact of television viewing on school, suggesting that the initial positive association might be spurious.[4] The negative correlation between television viewing and academic achievement persists regardless of whether using standardized scores or scores derived from the Rasch model, which takes into account the relative ability of the students and the relative difficulties of questions. These findings are consistent across four grades in primary and junior high school.

Our paper is organised as follows. Section 2 describes the transition from analog to digital TV, which is our natural experiment. Section 3 describes the data on pupil achievements used in our analysis. In section 4, we present our empirical strategy, while in section 5, we present our empirical findings, including some heterogeneity in impact. Section 6 concludes.

2 From analogical to digital TV

Until 2007, the period preceding the commencement of the transition from analog to digital TV signal transmission, Italy featured a notably concentrated television market. Through the analog signal, viewers had access to seven national channels, with the six major channels collectively holding about 85% of the total TV viewing shares. The primary components of the Italian public broadcasting system (Rai) were the Rai1, Rai2, and Rai3, while the privately-owned trio of Rete4, Canale5, and Italia1 was under the control of Mr. Berlusconi through his media conglomerate, Mediaset. A seventh channel, LA7 (originally Tele Montecarlo), was owned by a private ICT company (Telecom Italia Media). The advertisement market was pressured to increase the number of channels, which required a different technology. Early attempts to introduce digital channels already occurred in the previous decade (Telepiù in 1990, Stream in 1996 and Sky Italia in 2003). Still, they were unable to coagulate sufficient pressure to force the entire country to make a transition.[5] Eventually, the law of November 29, 2007, No. 222, following a mandatory directive from the European Union (2007/65/EC), stipulated that the "transition to

[4]Another related paper is Kureishi and Yoshida (2013), who also instrument TV viewing hours with the number of viewable commercial broadcast channels in the prefecture of residence, finding that the more television a child views, the more likely it is for the child's mother to report negative performance of her child in school (but not on the speed of school lesson).

[5]According to AGCom (Autorità per le garanzie nelle comunicazioni, the Authority governing telecommunications) annual report for 2009, in 2008 (before the switch) the 94% of advertising revenues originated from terrestrial analog and 5% from satellites (table 1.39 at pg.78). Conversely, in March 2012 (switch almost completed), the corresponding revenue shares were 11% for the analog, 72% for the digital, and 16% for the satellite (AGCom 2013 annual report, table 2.45, pg. 139). The impact of the transition on content supply is discussed in Barra et al. (2024).

digital" (terrestrial) had to be completed by December 31, 2012. Italy was divided into sixteen areas (see Figure 1), each assigned a specific date for the analog switch-off. Over four years, from November 2008 to June 2012, the digital switchover for the entire country was successfully implemented. Terrestrial digital TV technology enhances transmission efficiency, which has allowed Italian households to receive new channels freely.

The staggered introduction of the digital TV signal is discussed in Mastrorocco and Minale (2018) who argue the plausible exogeneity of the change by using data on effective viewing. According to their analysis (see in particular their figure 4), the effect induced by the Digital Reform is the loss of market share by traditional channels, the introduction of new digital channels offering TV shows, movies, and programs for kids, and, a lesser extent, sports programs, educational/history programs, and lifestyle programs. In table A1 in the Appendix, we report the supply of digital channels that were available in 2010, one year after the start of the transition: Italian children got access to 7 new channels designed for their entertainment, accompanied by six new channels devoted to cultural and scientific information.

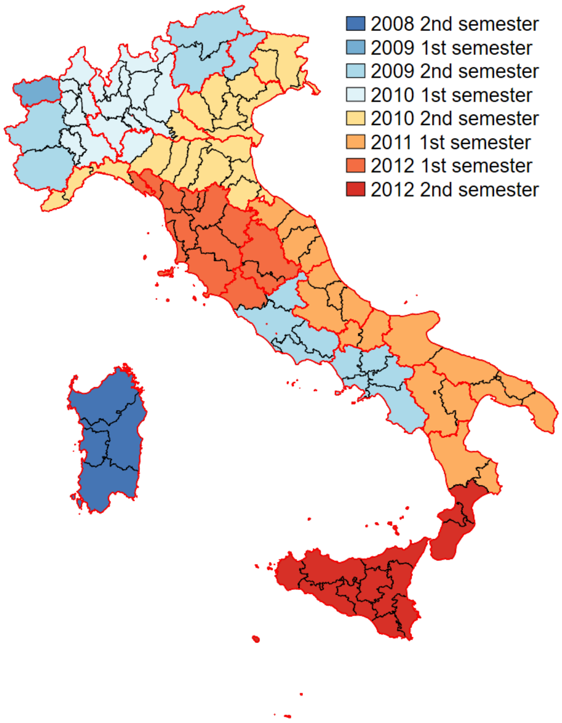


Figure 1. Timing of switch-off across Italian regions - Source: Italian Ministry of Communication.

However, the sharp switch off of analogic channels with general contents does not prevent access to digital channels earlier. Data on content viewing are of little help, given the small sample size when considering families with children aged between 6 and 13. Indirect evidence can be obtained from data on decoder ownership sourced from the Multipurpose Household Survey conducted by the Italian National Statistical Institute (ISTAT). This annual survey collects information on household opinions across a range of topics while also gathering detailed data on family composition and housing characteristics. A specific module, Aspects of Daily Life, provides granular insights into the daily activities of individuals and households. The survey is conducted each year in March and employs a repeated cross-sectional design that is repre-

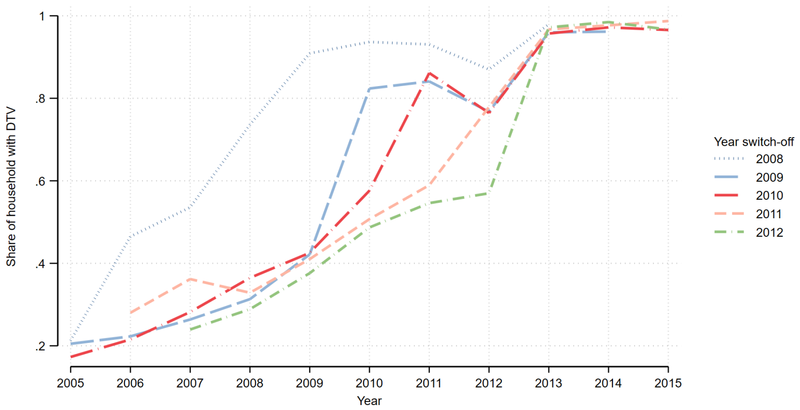


Figure 2. Possession of digital decoder by region/year of analog switch-over – Household with children aged 6-13 – Multiscopo survey

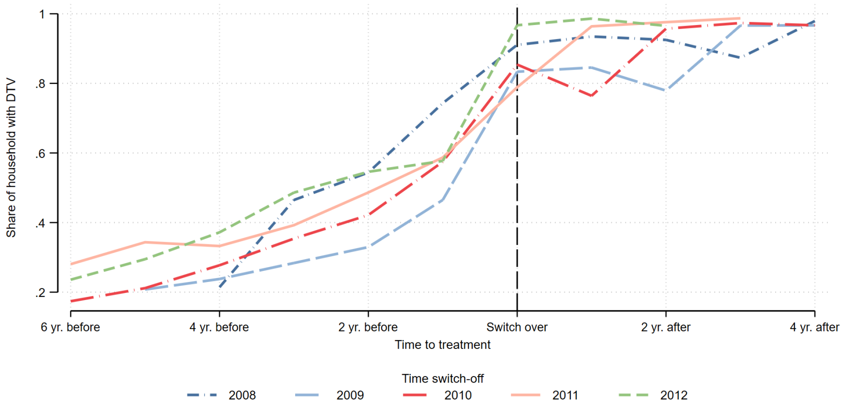


Figure 3. Possession of digital decoder by time distance from analog switch-over – Household with children aged 6-13 – Multiscopo survey

sentative of the regional level of the Italian population. The sample comprises approximately 48,000 individuals annually, corresponding to around 19,000 households, with roughly 14% of these households including school-age children. Unfortunately, Istat only provides the region of residence, so the match with the switch-off date is imperfect. In Figure 2, we report the fraction of households with children who possessed a digital decoder, an indispensable tool to access digital channels. If we exclude Sardinia provinces that switched in 2008, by 2009, approximately 40% of Italian households already possessed a decoder. By the time of the switch, the government fully subsidised the purchase of a decoder through vouchers. However, the limited cost (less than 200 euro) did not prevent households living in regions that had not yet switched off the analog channel from experiencing digital channels in advance. This anticipation effect is, however, correlated with the "novelty" effect created by the appearance of new digital channels. Looking at figure 3, one can notice that the anticipatory behaviour increases while getting closer to the final switch-off year of 31/12/2012.

There is some heterogeneity in this anticipation effect, as evident from figure 4, where we compute the share of decoder owner by maximal educational attainment in the parental couple. 'early compliers' tend to be more educated than late ones, possibly due to income availability. Despite the switch-over exogeneity to schooling, the existence of anticipatory behaviour pre-

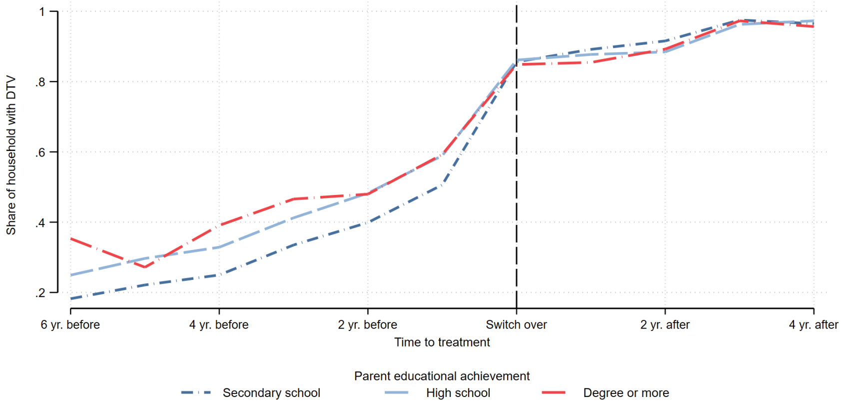


Figure 4. Possession of digital decoder by time distance from analog switch-over and maximal parental education – Household with children aged 6-13 – Multiscopo survey

vents us from considering the exposure to new digital channels as a purely random treatment. However, switching off previous analog channels forces everyone to transition to digital. Consequently, we shall interpret this experiment as an "intention to treat" (ITT) that provides a lower bound estimate of the actual effect of the treatment on the treated.

3 Student achievements

To investigate the impact of expanded access to TV content on student achievements, we have resorted to data collected by the National Agency for Student Testing, INVALSI, which started surveying Italian pupils during the school year 2009-10. We are, therefore, prevented from studying the years preceding the DTT. We were provided with existing surveys for four school years (from 2009-10 to 2012-13) that covered the entire population over the transition period of digital TV. In the initial years, INVALSI tested their literacy and numeracy competencies in grades 2, 5, 6 and 8, which constitute our sample.[6] Surveys are typically conducted in the early spring of each year, on the same date in each grade for the entire country. Therefore, we have four dates of student assessment to be matched with eight dates of switch to digital TV.

Invalsi data contains the item response for each pupil in each class, which are then aggregated in two ways: a) simple count of correct answers (*punteggio grezzo*), standardized to have zero mean and unitary standard deviation; b) estimate of student true ability using a Rasch model, that takes into account the different level of difficulty in answering each item and the different level of preparedness of each student. For comparability reasons, it is also normalized. The correlation among the two measures of achievement in literacy (Italian language) is 0.96 in grade 2, 0.96 in grade 5, 0.98 in grade 6 and 0.97 in grade 8 (corresponding values for numeracy (Mathematics) are 0.96, 0.97, 0.99 and 0.98 respectively).[7]

[6]Survey in grade 6 was abandoned in 2013-14 when it became possible to track each student with a longitudinal code (*codice SIDI*). For this reason, we cannot track the same individual over several surveys, and it must be considered a collection of cross-sectional data. The survey in grade 10 was introduced in 2010-2011 and, therefore, has been excluded from the present analysis. In the initial year, INVALSI also collected grades 5 and 6 information on pupil attitudes, including time use (*questionario studente*). Later on, it was extended to grades 8 and 10.

[7]The Rasch estimate by Invalsi is available from the school year 2011-12. Consequently, we had to independently

In addition to test scores, the survey contains limited information on the school activities (the class and school anonymized identifiers, the number of weekly hours spent in school and official grades received by the pupil in Italian and Mathematics)[8], but rich information on socio-economic conditions. In addition to gender, age (coded as deviation from the modal age cohort), and country of birth, they include the province of residence, maximal parental education, occupation and citizenship, and whether they have attended ECEC or pre-primary education. In grade 8, only administrative information (gender, age and birth country) is available. Descriptive statistics by grade are reported in table 1. Notice that in the final row of the table, we have added two alternative treatment measures that will be used in the sequel. The first (treatment) is a dummy variable, varying by province and year, corresponding to one when a province/year has switched-over to digital. The second one (distance) measures the number of months missing to the switch-over in the province/year. The main difference between the two is that the former treatment variable takes one value per year (either zero or one). In contrast, the latter treatment variable takes two values per year since the switch-over occurred every semester. The difference is evident when looking at tables 2 and 3. In table 2, we report the fraction of treated students in each spring of the survey year. By 2010 (the first surveys available), a fourth of the Italian pupils were residing in provinces that had already switched to digital and, therefore, were not affected by the natural experiment and will be excluded from the analysis. In table 3, we report the average number of months missing to the switch-over (negative values indicating time passed from the switch). The substantial difference between the two treatment measures is that the second one does not require the exclusion of students residing in treated provinces, on the argument that it may take time to exert some impact on students' achievements.

apply the Rasch model using the corresponding R routine for all the years under consideration. It essentially corresponds to a non-linear transformation of the original raw data, as illustrated by Figures A1 and A2 in the Appendix. The correlation between our Rasch model and the one produced by INVALSI is as follows: for literacy, it is 0.96 for Grade 2, 0.98 for Grade 5, 0.97 for Grade 6, and 0.97 for Grade 8; for numeracy, the correlation values are 0.99, 0.80, 0.999, and 0.99, respectively. In the early years, tests were administered on paper, and class teachers were responsible for manually entering students' answers into a spreadsheet. This process created an incentive to adjust incorrect answers within their class, artificially inflating class performance (cheating), even though it did not affect teacher salaries. To mitigate the risk of such behaviour, INVALSI implemented a system where external examiners were tasked with entering the data for a subset of classes (*classi campione*). The scores recorded in these externally monitored samples were consistently lower on average, providing evidence to support initial concerns about potential cheating. See Bertoni et al. (2013). Starting with 2011-12, INVALSI estimates the probability of cheating at class level based on student similarity patterns and proposes a corrected test score. Given the impossibility of replicating the algorithm, we have used the raw data, though introducing a control for the presence of external controllers.

[8] If schools identifiers were not changed within our sample period, the best strategy for cleaning away unobserved school features would have been the inclusion of school fixed effects. Unfortunately, this is not the case, and we were forced to replace them with within-sample statistics at the school level (share of females, share of natives, share of repeaters, average of parental education and occupation, log of school size) accompanied by province-fixed effects.

Table 1. Descriptive statistics

	Grade 2	Grade 5	Grade 6	Grade 8
test score in numeracy	0.00828	0.00891	0.00405	0.00184
	(0.995)	(0.996)	(0.996)	(0.997)
Rasch numeracy	0.0225	0.0156	0.00698	0.00630
	(1.258)	(1.133)	(0.996)	(0.925)
test score in literacy	0.00938	0.0145	0.0129	0.00537
	(0.993)	(0.983)	(0.980)	(0.991)
Rasch literacy	0.00563	0.288	0.00883	0.00449
	(1.192)	(1.040)	(0.940)	(0.927)
female	0.496	0.497	0.489	0.500
	(0.500)	(0.500)	(0.500)	(0.500)
age (1=normal age)	-0.0897	-0.0716	-0.0244	0.0273
	(0.342)	(0.354)	(0.411)	(0.426)
born in Italy	0.929	0.911	0.890	0.911
	(0.257)	(0.284)	(0.313)	(0.285)
Par.education: less than secondary	0.468	0.499	0.534	
	(0.499)	(0.500)	(0.499)	
Par.education: upper secondary	0.343	0.339	0.318	
	(0.475)	(0.474)	(0.466)	
Par.education: college	0.189	0.161	0.148	
	(0.392)	(0.368)	(0.355)	
Par.occupation: blue collar/unemployment	0.428	0.427	0.448	
	(0.495)	(0.495)	(0.497)	
Par.occupation: service class	0.359	0.363	0.352	
	(0.480)	(0.481)	(0.478)	
Par.occupation: high class	0.213	0.210	0.200	
	(0.409)	(0.407)	(0.400)	
father or mother born abroad	0.104	0.0977	0.102	0.0965
	(0.305)	(0.297)	(0.303)	(0.295)
attended early childcare	0.218	0.186	0.179	
	(0.413)	(0.389)	(0.383)	
attended pre-primary	0.809	0.807	0.751	
	(0.393)	(0.395)	(0.432)	
weekly hours in school	32.41	32.21	31.24	
	(5.409)	(5.024)	(2.450)	
External control (classi campione)	0.0629	0.0624	0.0728	0.0511
	(0.243)	(0.242)	(0.260)	(0.220)
treatment (access to digital)	0.679	0.670	0.664	0.673
	(0.467)	(0.470)	(0.472)	(0.469)
distance (months)	8.793	8.337	8.062	8.637
	(18.03)	(18.09)	(18.05)	(18.29)
Observations	1909964	1913911	2045985	2057870
Obs2010	466536	475343	518945	497564
Obs2011	475964	497257	529125	522870
Obs2012	487575	473874	516636	519001
Obs2013	479889	467437	481279	518435

Notes: Standard errors in parentheses

Table 2. Percentage of students in treated provinces

	Grade 2	Grade 5	Grade 6	Grade 8
Treatment	67.88	67.01	66.41	67.34
2010(excluded)	28.64	29.12	29.18	29.64
2011	64.83	63.89	63.75	63.04
2012	76.78	75.73	75.26	75.17
2013	100	100	100	100

Table 3. Distance to treatment in months

	Grade 2	Grade 5	Grade 6	Grade 8
Months to treatment	8.793	8.337	8.062	8.637
2010	-9.370	-9.466	-9.515	-9.574
2011	2.633	2.476	2.501	2.411
2012	14.64	14.47	14.40	14.50
2013	26.62	26.46	26.32	26.54

For two grades (5^{th} and 6^{th}), INVALSI asks the pupils to provide additional information on their self-confidence in answering the test, on their time use during a typical day and on educational resources available at home. We exploit the second and third groups of variables to explore the channels of the experiment impacts. Descriptive statistics are in table 4. Unfortunately, this questionnaire was not collected in the second year of our sample (2010-11), thus limiting the possibility of comparing the hours of TV watching during the introduction of digital channels.

Table 4. Descriptive statistics from supplementary questionnaires in grade 5 and 6

	Grade 5	Grade 6
0-10 books	0.138	0.117
	(0.345)	(0.322)
11 -25 books	0.269	0.247
	(0.444)	(0.431)
25 - 100 books	0.314	0.315
	(0.464)	(0.465)
100 -200 books	0.156	0.175
	(0.363)	(0.380)
More than 200 books	0.124	0.145
	(0.329)	(0.352)
Daily hours watching TV	1.151	1.268
	(0.752)	(0.753)
Daily hours spent on PC	1.092	1.183
	(0.824)	(0.843)
Daily hours spent reading	0.778	0.702
	(0.743)	(0.727)
Weekly hours spent on homeworks	4.082	
	(1.681)	
Daily hours spent on homeworks		1.749
		(0.736)
Observations	1474499	1526199

Notes: Standard errors in parentheses

4 Identification strategy

Our empirical strategy investigates the causal effect of digital television exposure on pupil performance in Italy, as measured by standardized INVALSI results in literacy (ITA) and numeracy (MATH). We explore this relationship using a difference-in-differences (DID) model. This model exploits the DTT rollout as a natural experiment. The "treatment group" will comprise pupils residing in areas that received DTT earlier, experiencing a potential increase in television access compared to the "control group" in areas with later DTT implementation. By isolating the effect of the timing difference in DTT access, the DID model aims to provide a robust estimate of the causal effect of television exposure on academic performance in Italy. The appearance of student testing when the treatment was already underway requires excluding "already treated" students when the treatment is a dummy variable. In addition, the absence of a pre-trend observation period prevents us from studying the staggered implementation using an even-DD strategy.

The introduction of DTT resulted in the availability of additional channels in the television industry, some of them directly targeted to children, supplementing the existing seven conventional national free-to-air channels with an increased variety of over 50 new channels. As a result, adopting DTT could have modified viewers' preferences towards traditional television programs. The partition of Italy into 16 areas, partly corresponding to regions, was based on the similarity of infrastructures from the 1950s. This division ensured that the switch-off deadlines were determined objectively and couldn't be manipulated by local politicians or interest groups. To analyse the effects of the staggered implementation of DTT and capture the changes before and after its introduction, we employ a difference-indifferences (DID) approach to compare the test scores of children residing in provinces who received digital television access at different points in time. This approach allows for controlling unobserved time-invariant factors that may influence television viewing and academic performance. The model is specified as follows:

$$Y_{irst} = \beta \text{Treatment}_{rt} + \gamma X_{irst} + \delta Z_{st} + \mu_r + \lambda_t + \varepsilon_{irst} \tag{1}$$

where i denotes the child, r represents the child's province of residence s, refers to the attended school, and t indicates the year of test administration. Y_{irst} measures the Invalsi test score achieved by student in year t. Treatment_{rt} is a treatment indicator: it may be either a dummy variable (assuming a value of 1 in the year (and subsequent years) when the digital television transition occurred in province r) or a continuous variable given by the number of months missing to the switch-over. By leveraging data on the digital switch-over across all Italian provinces, we capture robust exogenous variation at a high granular geographic level (over one hundred provinces). λ_t represents a set of year-fixed effects that control for the average INVALSI test score fluctuations over time, while μ_r introduces province-fixed effects that control geographical achievement differences. δ accounts for school-specific features (like the time-varying share of females or natives, school size and the like). X_{irst} is a vector of covariates that vary across children and over time. It includes comprehensive information on the students, covering gender, age, country of birth, and past attendance at kindergarten or daycare. Additionally, parental data enriches our understanding of the student's socioeconomic status, including parental educational qualifications, occupational types, and the number of books at home. ε_{irst} represents the error term, varying at the student and time level. Standard errors are clustered at the school level. The empirical strategy hinges on the assumption that the switch-over deadlines are exogenous and not correlated with unobserved determinants of education after controlling for the aforementioned observable covariates, year-fixed effects and province-fixed effects.

As mediation analysis, we consider the time spent watching TV as a possible pass-through of the effect of media access on student learning. Introducing Digital Terrestrial Television (DTT) may not directly impact academic grades, but it can significantly influence children's television viewing habits, potentially affecting their academic performance. This is because DTT offers a broader range of channels than traditional terrestrial TV, which may lead children to spend more time browsing and watching. Additionally, the sharper visuals offered by DTT make TV shows more engaging and potentially harder for children to turn away from. Consequently, the potential influence of digital terrestrial television (DTT) on student academic achievement may be mediated by the volume of television viewing time. Increased screen time can potentially affect academic performance in several ways. Firstly, prolonged television viewing reduces the time available for homework, studying and completing school projects (*substitution effect*). Secondly, excessive TV watching can disrupt sleep patterns, leading to fatigue and decreased concentration in school. Lastly, while DTT introduces more educational shows, a significant portion of TV content remains entertainment-focused, which may not directly contribute to academic achievement. On the other hand, TV may provide information and cultural content that would be otherwise inaccessible for pupils from less educated environments. The most evident example is language: TV programmes represent a valuable source for language learning (*compensatory effect*) in families where dialects or foreign languages are spoken. Finally, the increased richness of contents may stimulate student curiosity, thus empowering them with additional knowledge, especially when they are largely stimulated by the family environment (*enrichment effect*). Whether one or the other effect is prevailing may vary across gender, age, citizenship and social origins.

To examine the association between television exposure and student performance on score tests, we regress INVALSI scores onto time spent watching TV, controlling for additional covariates. Formally, our regression equation takes the following form:

$$Y_{irst} = \sigma \text{TVtime}_{irst} + \gamma X_{irst} + \delta Z_{st} + \mu_r + \lambda_t + \varepsilon_{irst} \quad (2)$$

where the variable has been defined with reference to equation (1). $TVtime_{irst]}$ is the amount of TV viewing self-declared by the student.[9] While OLS yields a positive correlation

[9]TVtime is the answer to the following question: "During a typical day, how many hours do you usually spend on each of the following activities outside of school?" where the alternatives available are a) Watching television (including videotapes or DVDs); b) Using the computer or playing video games (PlayStation®, Xbox®, Nintendo DS®, Wii®, or other gaming consoles); c) playing with friends; d) Helping out at home; e) Reading a book or comics for leisure. For each activity, it is possible to provide four mutually excluding answers: none, less than one hour, between 1 and 2 hours, and more than two hours. We have recorded them as 0, 0.5, 1.5 and 2.5, but this discretization prevents exploring potential nonlinearities.

(i.e. σ takes a positive and statistically significant sign), we suspect the potential endogeneity of viewing time, where students with different unobservable abilities might naturally watch more or less television, leading to a spurious correlation. We then introduce a two-stage instrumental variable (IV) approach to address the potential endogeneity.

We instrument $TVtime_{irst}$ with a source of exogenous variation W_{rt} (varying by province and year, as in our experiment) or W_{st} (varying by school and year, if available). The first stage of this model can be written as:

$$\text{TVtime}_{irst} = \alpha_0 + \eta W_{rt} + \gamma_0 X_{irst} + \delta_0 Z_{st} + \mu_{0r} + \lambda_{0t} + \omega_{irst} \tag{3}$$

As an instrument, we consider two alternatives: the first alternative is whether residing in a province that has already switched off the analog channel (our treatment variable), and the second alternative is the distance (in months) from the switch-off date that predicts access to television without directly affecting school performance (our distance variable). This temporal variation in access allows for isolating the causal effect of television exposure. The second stage leverages the instrumented time passed watching TV by pupils, regressing INVALSI scores on the predicting TV viewing. We find mixed results that suggest local schools' potential role in mediating this DTT effect. We have also explored a third alternative offered by weekly hours spent in school, which captures time dedicated to formal learning and is expected to correlate negatively with television viewing due to time constraints. A possible objection is its potential correlation to student achievements, violating the independence assumption. However, when conditioning on province and survey fixed effect, literacy and numeracy exhibit a negative correlation with hours spent in school (except for numeracy in grade 6 – data on hours are not available for grade 8). Thus, we also present these results even though we are aware of the debatability of this instrument.

5 Results

5.1 Difference in differences approach

In Figure 5, we report the βs obtained by estimating model (1) in the sample constituted by the province that are going to be treated over the period 2009-2012.[10] All the estimated coefficients in grades 2 and 5 are negative and statistically significant. Negative coefficients are also obtained in grade 6 (except in the case of Rasch numeracy) and the case of numeracy in grade 8. In terms of magnitudes, exposure to numerous digital channels lowers students' test scores by less than one-tenth of the standard deviation, more in numeracy than literacy. Interpreting the β as an Average Treatment Effect on the Treated (ATT) can be problematic when there is an anticipation effect. This effect occurs when participants alter their behaviour because they anticipate receiving the treatment. Consequently, the estimated treatment effect may not accurately reflect

[10] The same findings have been organized and presented in a structured manner in tabular form, which can be found in Appendix Table A2. Comparable results can be replicated without excluding the already treated observations; these are reported in Appendix Figure A3 and Table A3.

the intervention's true effect, as it includes changes driven by participants' expectations rather than the intervention itself. In such cases, using an Intention to Treat (ITT) approach is preferable. ITT preserves the initial random assignment of participants and includes all individuals as originally allocated, regardless of their adherence or behaviour changes due to anticipation. Therefore, we should interpret our results as ITT, representing a lower bound estimate of the true effect.[11] If we consider a varying intensity treatment based on time distance from the switch-over, we find rather similar results, with negative impact in all grades but literacy in 6^{th} grade.[12]

The classic Difference-in-Differences estimator, while widely employed, relies on restrictive assumptions, notably the homogeneity of treatment effects across units and parallel trends between treatment and control groups. Furthermore, in settings with staggered treatment adoption, the standard DiD approach can yield biased estimates due to the implicit assignment of negative weights to early adopters (Goodman-Bacon, 2021). Recent literature has highlighted the critical importance of addressing potential biases arising from treatment effect heterogeneity, particularly when treatment timing varies across individuals (Callaway and Sant'Anna, 2021; Sun and Abraham, 2021).

To address these limitations, we employ the robust methodology proposed by Callaway and Sant'Anna (2021) to estimate Equation (1). Specifically, we utilize the 'hdidregress' Stata routine, which estimates Average Treatment Effects on the Treated that can vary both over time and across treatment cohorts in repeated cross-sectional data, implementing the aforementioned methodology.[13] This approach mitigates the biases inherent in the Two-Way Fixed Effects DiD model by leveraging a series of 2x2 DiD comparisons, focusing on credible control groups and avoiding the problematic weighting of early-treated units. Causal effects are identified for each treated cohort and subsequently aggregated using non-negative weights, thus accommodating heterogeneous treatment effects and staggered treatment adoption. Crucially, this methodology relaxes the parallel trends assumption, allowing for the inclusion of covariates in a flexible manner, and facilitates diverse aggregation schemes for summarizing treatment effects. These features render it particularly suitable for analyzing contexts characterized by staggered treatment initiation, such as the Digital Terrestrial Television rollout examined in this study.

The estimated treatment effects are presented in Section A.1. Estimates are reported for each grade and subject, employing both regression adjustment and augmented inverse probability weighting, which yield consistent results. Pre-treatment effects are statistically insignificant, supporting the validity of the parallel trends assumption. Post-rollout, the findings are consistent with those presented in Table A3, revealing negative effects for the 2^{nd}, 5^{th} , and 8^{th} grades, and positive effects for the 6^{th} grade.

The robustness of these findings to treatment effect heterogeneity is a key contribution of this analysis. The concordance between the estimates obtained using the Callaway and Sant'Anna

[11]The dilution of the effect of treatment is also visible when we include all provinces in the estimation sample, as it is done in table A3 in the Appendix. In such case, the estimated βs halve, and some negative statistical significance is gained in grade 8.

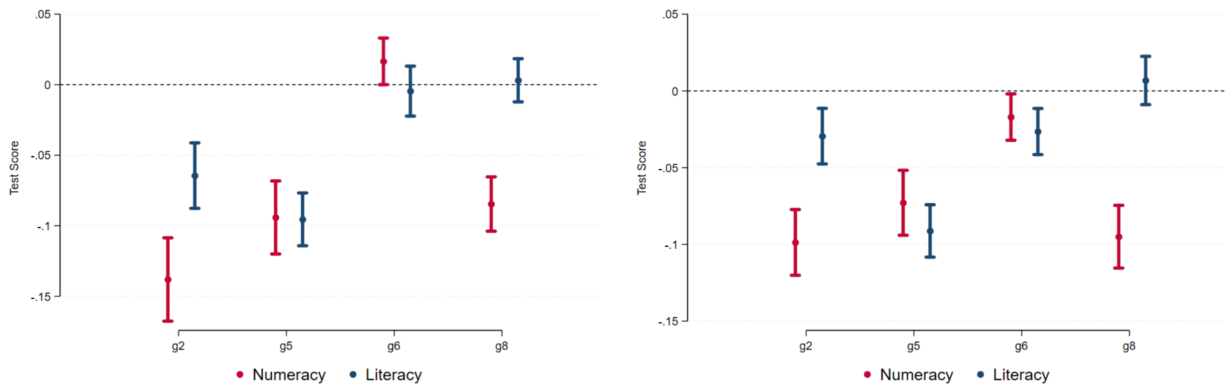
[12]See table A4 in the Appendix.

[13]The `hdidregress` Stata routine, employed for estimation, implements the methodology of Callaway and Sant'Anna (2021) to estimate ATTs that are heterogeneous with respect to time and treatment cohort in repeated cross-sectional data.

approach and those derived from the TWFE method reinforces the reliability of our results and underscores the importance of accounting for treatment effect heterogeneity in settings with staggered treatment adoption.

Despite the robust consistency of the negative impact of digital transition, one may wonder whether this impact is uniform across pupils. To explore potential heterogeneity, in table 5, we interacted with three individual characteristics: gender, citizenship and family background (proxied by not having a college-educated parent). We observe that the benchmark case (native boy with at least a college-educated parent) is always negatively affected by the treatment across all grades. However, what is most interesting is that foreign-born children experience a reversed impact, even though the order of magnitude is insufficient to counterbalance the negative impact. This suggests that the availability of a broader set of digital TV channels constitutes an additional beneficial educational resource. A similar (but statistically weaker) effect is also recorded for children of less educated parents. Overall, these results suggest that TV supply exerts a substitution effect for the entire population, with a stronger negative impact for the female component, but it plays a complementary positive effect for non-natives and children from culturally poor backgrounds.

Figure 5. DiD estimate (excluding provinces already treated in 2009-10)



(a) Rasch

(b) Stardized test score

Table 5. DiD estimate (excluding provinces already treated in 2009-10) – interactions with observables

	(1) numeracy	(2) Rasch numeracy	(3) literacy	(4) Rasch literacy
	Grade 2			
treatment	-0.084***	-0.107***	-0.110***	-0.078***
	(0.013)	(0.016)	(0.012)	(0.015)
treatment × female	-0.035***	-0.048***	-0.010***	-0.039***
	(0.003)	(0.004)	(0.003)	(0.004)
treatment × foreignborn	0.122***	0.146***	0.085***	-0.016
	(0.010)	(0.013)	(0.011)	(0.013)
treatment × nocollege	-0.062***	-0.077***	0.019***	0.111***
	(0.007)	(0.009)	(0.006)	(0.008)
Observations	1369197	1369197	1374241	1374241
Adjusted R^2	0.085	0.088	0.082	0.079
Number of schools	6025	6025	6023	6023
	Grade 5			
treatment	-0.073***	-0.094***	-0.187***	0.244***
	(0.011)	(0.013)	(0.011)	(0.012)
treatment × female	-0.048***	-0.057***	0.054***	0.053***
	(0.004)	(0.004)	(0.003)	(0.004)
treatment × foreignborn	0.090***	0.102***	0.120***	0.045***
	(0.009)	(0.010)	(0.010)	(0.010)
treatment × nocollege	-0.020***	-0.017*	0.004	0.014*
	(0.007)	(0.009)	(0.006)	(0.007)
Observations	1356308	1356308	1364787	1364787
Adjusted R^2	0.074	0.071	0.102	0.113
Number of schools	6031	6031	6027	6027
	Grade 6			
treatment	-0.095***	-0.115***	-0.192***	-0.182***
	(0.010)	(0.010)	(0.010)	(0.010)
treatment × female	-0.047***	-0.038***	0.060***	0.061***
	(0.004)	(0.004)	(0.004)	(0.004)
treatment × foreignborn	0.111***	0.114***	0.103***	0.135***
	(0.007)	(0.008)	(0.008)	(0.008)
treatment × nocollege	0.002	0.029***	0.047***	0.016***
	(0.007)	(0.007)	(0.006)	(0.006)
Observations	1393991	1393991	1396582	1396582
Adjusted R^2	0.131	0.127	0.181	0.164
Number of schools	5018	5018	5018	5018
	Grade 8			
treatment	-0.143***	-0.114***	-0.230***	-0.184***
	(0.009)	(0.008)	(0.010)	(0.009)
treatment × female	-0.099***	-0.101***	-0.011***	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)
treatment × foreignborn	0.131***	0.116***	0.206***	0.164***
	(0.009)	(0.008)	(0.010)	(0.009)
Observations	1450953	1450953	1452584	1452584
Adjusted R^2	0.070	0.067	0.113	0.099
Number of schools	5012	5012	5012	5012
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), the share of female/native/repeaters at school level, (log of) school size, whether external control during test + years and province fixed effects - Further controls for grades 2-5-6 are parental education and occupation, ECEC and preprimary attendance, weekly hours of school attendance, the share of educated and high-class parents in the school.

5.2 Time use and test scores

As we said in the data description section, for a subset of surveys (grades 5 and 6 over the school years 2009-10, 2011-12 and 2012-13), we possess additional information on time use, as self-reported by the pupils. In table 6, we replicate the Diff-in-Diff approach using hours in different competing activities as dependent variables.In the appendix, Table A5 presents the results obtained using distance as the primary independent variable, rather than the treatment indicator.[14] It represents a sort of first stage when we will instrument the hours of TV watching to predict test scores. While restricting to provinces that were not treated in the initial year (and despite the lack of an intermediate year), we observe in table 6 that the DTT led to a reduction of time spent on TV watching and game playing on PC, at least in grade 5. In contrast, in grade 6, it ended up as statistically insignificant. This result is somewhat surprising since the two grades are close in age. However, school organization is slightly different: grade 5 falls into primary education, often imparted as full-day schools, with one or two teachers as a reference; on the contrary, grade 6 represents the start of junior high school, extends only to half-day requiring some time spent in homeworking, assigned by a multiplicity of teachers. Thus, compared to 5^{th} graders, pupils in grade 6 experience greater freedom in time use, which is associated with a greater demand for self-control, which may explain the statistical irrelevance of the greater availability of digital channels. This interpretation is further supported by the results presented in column 4, which analyze the relationship between digital channel availability and time spent on homework. The analysis uses different measures for the two grades: weekly homework hours for grade 5 and daily homework hours for grade 6. Although these measures are not directly comparable due to differences in their scales and contexts, the direction of the estimated parameters offers valuable insights.

Specifically, the results suggest a shift in how students allocate their time as digital channel availability increases, which may vary in magnitude and significance depending on the grade level.

It would be interesting to ascertain whether greater availability of TV content exerts a differential effect according to a child's development stage, as it would be possible using longitudinal data. The initial survey of INVALSI does not allow tracking the same individual along the tests, especially when there is a one-off transition. In principle, we can identify the same age cohort that was attending grade 5 in 2011-12 and grade 6 in 2012-13: in such a case, the same pupil is observed twice at two different ages, and the effect of the treatment is identified by a student living in provinces that experience the transition in the final year. Results obtained by restricting this subsample are reported in the bottom part of table 6, where we observe a shift from attention to TV watching accompanied by more time spent on PC or book reading.

[14] In the appendix, Table A5 presents the results obtained using distance as the primary independent variable, rather than the treatment indicator.

Table 6. Time use and digital reform (excluding provinces already treated in 2009-10)

	watching TV	playing games on PC	reading books	with friends	helping at home
	(1)	(2)	(3)	(4)	(5)
			grade 5 - 2010-2012		
treatment	0.011**	0.014**	-0.009*	0.025***	0.001
	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
Observations	666992	667042	667818	665067	666518
Adjusted R^2	0.017	0.095	0.065	0.013	0.049
Number of schools	5392	5392	5393	5393	5393
			grade 6 - 2010-2012		
treatment	0.004	0.003	-0.026***	0.021***	-0.007
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
Observations	704970	705155	705485	703825	704273
Adjusted R^2	0.023	0.090	0.077	0.023	0.045
Number of schools	4382	4382	4381	4382	4382
			grade 5 in 2012 - grade 6 in 2013		
treatment	-0.024***	0.010*	0.007	0.076***	-0.015***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)
Observations	675135	675092	675284	673614	674686
Adjusted R^2	0.024	0.102	0.080	0.015	0.049
Number of schools	6545	6545	6545	6545	6545
Prov FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), whether external control during test, number of books at home, parental education and occupation, ECEC and preprimary attendance, weekly hours of school attendance, share of educated and high-class parents in the school, share of female/native/repeaters at school level, (log of) school size + years/grade and province fixed effects.

If we now move to the correlation between TV watching and student test scores, we constantly find a positive correlation, as evident from table 7, where we control for a bunch of confounders.[15] The magnitude of the association is small but not negligible: an additional hour of watching TV is associated with 2.5 to 3 percentage points of a standard deviation. The association is more substantial in grade 5 than in grade 6, consistent with what is found in table 6 on

[15] See table A6 and table A7 in the Appendix for the entire model, where we obtain standard results: girls consistently score lower in numeracy but higher in literacy compared to boys across both grades. The age of the student (coded as -1 when younger than the modal age and +1 when older) displays a weak but statistically significant negative correlation with test scores in Mathematics and Italian for grade 5 students, with a more pronounced effect observed in grade 6: this indicates that repeaters are already penalised when compared to regular students in terms of achievements. Students with a migratory background (at least one parent born abroad and/or being born abroad themselves) obtain lower scores: combining the two conditions reduces the average score by half a standard deviation. A noteworthy positive correlation is observed with the number of books at home. Finally, students with parents holding higher educational qualifications (upper secondary school or university) consistently achieve statistically significantly higher scores in numeracy and literacy compared to those with poorly educated parents, irrespective of grade level. Contrary to our expectations, attending early childcare, when statistically significant, is negatively correlated with achievements, but the sign is reversed when considering pre-primary education attendance: both are likely interconnected with the occupational condition of parents (especially mothers), and therefore, it isn't easy to interpret. Finally, the regression controls for school-level information that is hard to interpret (except for the case of external control presence, which reveals the possibility of teacher cheating when uploading the results).

time use.

Table 7. Student achievements and TV watching hours (excluding provinces already treated in 2009-10) - OLS

	(1) numeracy	(2) Rasch numeracy	(3) literacy	(4) Rasch literacy
	grade 5 - 2010-2012-2013			
TV watching hours	0.021***	0.022***	0.017***	0.016***
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	665927	665927	647905	647905
Adjusted R^2	0.101	0.098	0.125	0.189
Number of schools	5392	5392	5391	5391
	grade 6 - 2010-2012-2013			
TV watching hours	0.013***	0.012***	0.023***	0.019***
	(0.002)	(0.002)	(0.002)	(0.001)
Observations	704025	704025	703129	703129
Adjusted R^2	0.145	0.143	0.200	0.196
Number of schools	4382	4382	4382	4382
	grade 5 in 2012 - grade 6 in 2013			
TV watching hours	0.024***	0.025***	0.017***	0.015***
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	673425	673425	665405	665405
Adjusted R^2	0.108	0.098	0.163	0.229
Number of schools	6541	6541	6539	6539
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), whether external control during test, number of books at home, parental education and occupation, ECEC and preprimary attendance, weekly hours of school attendance, share of educated and high-class parents in the school, share of female/native/repeaters at school level, (log of) school size + years/grade and province fixed effects.

It is crucial here to acknowledge the risk of spurious correlations, given the omission of relevant variables like unobservable ability, motivation, self-control and the like. Even though research in this area has always made use of OLS regressions to assess the correlation between self-reported television viewing time and academic performance, the limitations of correlational studies are well-documented (Strasburger, 1986; Gentzkow and Shapiro, 2008), the validity of these studies hinging on the comprehensiveness of their control variables. Omitting key factors can lead to misleading associations: omitting individual unobserved ability may lead to a positive correlation since brighter students take advantage of TV content for learning while scoring high on tests; on the other hand, omitting psychological traits like self-control may produce a negative correlation, since better-organised students limit their leisure while performing better in tests. Given the limitations in the dataset, we cannot use OLS regression to assess the causal impact of TV viewing, and we need to explore alternative approaches to provide a more robust understanding of the causal relationship between these variables.

5.3 Evidence from an instrumental variable approach

Given the potential source of bias existing when examining the association between self-reported television viewing time and student test scores, in table 8, we present the results obtained using IV estimation when the instrument is the exposition of the province where the school is located. The results of grade 5 are consistent with what we have already found in the DiD analysis: TV watching negatively impacts student achievements, even though the instrument's power is limited.[16] On the contrary, results for grade 6 show no statistically significant impact of TV watching hours on achievement, which is also consistent with the change in sign and significance illustrated for the Rasch variant of the test score in figure A3. The lack of significance may also be related to the weakness of the instrument, as indicated by the corresponding test. To address the limitations associated with the provincial exposure instrument, we adopt an alternative instrument that incorporates greater heterogeneity: the distance to the switchover. This instrument captures more granular variability in the rollout of digital television, allowing us to retain observations from 2013 and thereby increase the statistical power of our analysis. The results of this analysis are reported in Table 9. For grade 5, the findings remain consistent with both the DiD analysis and the previous IV estimation, confirming a negative and statistically significant impact of television viewing on student achievement. For grade 6, the results reveal a negative and statistically significant effect of television hours on test scores. These findings align with the DiD analysis but must be interpreted cautiously due to the continued weakness of the instrument, as reflected in the low F-statistics. Finally, when using the hours spent in school, we find a reversed result for just grade 5: positive causal effect on literacy and negative on numeracy, both cases with identification tests beyond the threshold (see table A8 in the Appendix). Summing up, TV watching has a statistically significant detrimental effect on student achievement during 5^{th} grade while yielding a negative (but statistically insignificant) impact during the $6^{th]}$ grade. Results are similar when using school hours as instrument, while they are partially reversed when using month distance from switch-over.

[16]The absence of the 2010-11 survey reduces the variability of our instrument. In addition, province-fixed effects restrict the instrument's power to the changes that occurred in 2010-2012 and 2012-2013 (when all provinces switched over to digital). For the same reason, we do not report results for the cohort observed twice (2011-12 in grade 5 and 2012-13 in grade 6) since the only source of identification is given by the provinces switching in the final semester of the transition (Sicily and Calabria).

Table 8. Student achievements and TV watching hours (excluding provinces already treated in 2009-10 and the 2013 survey) – IV=treatment

	(1) numeracy	(2) Rasch numeracy	(3) literacy	(4) Rasch literacy
	grade 5 - 2010-2012-2013			
TV watching hours	-7.286*	-8.366*	-5.551**	-6.296**
	(3.875)	(4.550)	(2.783)	(3.184)
Observations	665927	665927	647905	647905
Number of schools	5392	5392	5391	5391
F Statistics	4.303	4.303	4.752	4.752
First stage	0.011**	0.011**	0.011**	0.011**
	(0.005)	(0.005)	(0.005)	(0.005)
	grade 6 - 2010-2012-2013			
TV watching hours	-7.901	-1.896	-25.070	-18.133
	(10.517)	(4.043)	(36.245)	(26.234)
Observations	704025	704025	703129	703129
Number of schools	4382	4382	4382	4382
F Statistics	.6	.6	.4744	.4744
First stage	0.004	0.004	0.003	0.003
	(0.005)	(0.005)	(0.005)	(0.005)
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), whether external control during test, number of books at home, parental education and occupation, ECEC and preprimary attendance, weekly hours of school attendance, share of educated and high-class parents in the school, share of female/native/repeaters at school level, (log of) school size + years/grade and province fixed effects.

Table 9. Student achievements and TV watching hours (excluding provinces already treated in 2009-10) IV= Distance

	(1) numeracy	(2) Rasch numeracy	(3) literacy	(4) Rasch literacy
		grade 5 - 2010-2012-2013		
TV watching hours	-0.323	-0.366	-1.053***	-13.647***
	(0.367)	(0.462)	(0.287)	(1.606)
Observations	1003142	1003142	974456	974456
Number of schools	6026	6026	6023	6023
F Statistics	26.37	26.37	24.01	24.01
First stage	4465.009***	4465.009***	23127.012***	23127.012***
	(0.000)	(0.000)	(0.000)	(0.000)
		grade 6 - 2010-2012-2013		
TV watching hours	-0.394	-0.780**	-0.484*	-0.244
	(0.338)	(0.349)	(0.289)	(0.269)
Observations	1044385	1044385	1044206	1044206
Number of schools	5010	5010	5011	5011
F Statistics	5.497	5.497	5.932	5.932
First stage	5280.223***	5280.223***	14832.559***	14832.559***
	(0.000)	(0.000)	(0.000)	(0.000)
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), whether external control during test, number of books at home, parental education and occupation, ECEC and preprimary attendance, weekly hours of school attendance, share of educated and high-class parents in the school, share of female/native/repeaters at school level, (log of) school size + years/grade and province fixed effects.

Finally, we have explored the potential heterogeneity of these results, given previously illustrated differences in the DiD estimation. The main problem in this framework is the limited number of instruments for the supposedly endogenous variable (hours of TV watching) and its interaction with the observable features of the pupils. Our strategy to cope with this limitation has also been interacting with the instrument and the observables of the pupil. In table 10, we report our most interesting results concerning foreign-born students and students from culturally poor environments. Regarding the first case, we observe that natives experience a strong negative impact on their achievements from TV watching. In contrast, the reverse impact is experienced by foreign-born pupils, both in 5^{th} and 6^{th} grades. When considering children from less educated parents, we find that they suffer an achievement loss, especially during 5^{th} grade in literacy, while children from college-educated parents experience a negative impact on numeracy from TV watching.[17]

[17]We have also explored the interaction of the treatment with self-perception of the students, on the expectation that self-controlled students experience lower damage from TV watching. However, the results are mostly statistically insignificant. Available from the authors.

Table 10. Student achievements and TV watching hours (excluding provinces already treated in 2009-10 and the 2013 survey) – IV=treatment

	(1) numeracy	(2) Rasch numeracy	(3) literacy	(4) Rasch literacy
		grade 5 - 2010-2012-2013		
TV watching hours	-2.561**	-2.157	-0.474	-2.770**
	(1.290)	(1.471)	(0.687)	(1.089)
foreignborn × TV watching hours	-0.002	-0.034	-0.238***	-0.080
	(0.076)	(0.086)	(0.041)	(0.064)
Observations	658239	658239	640526	640526
Number of schools	5391	5391	5390	5390
F Statistics	3.494	3.494	4.312	4.312
		grade 5 - 2010-2012-2013		
TV watching hours	-4.594**	-5.739**	-2.360**	-1.461
	(1.814)	(2.280)	(1.063)	(0.992)
nocollege × TV watching hours	-0.109***	-0.124***	-0.145***	-0.175***
	(0.028)	(0.035)	(0.017)	(0.015)
Observations	658239	658239	640526	640526
Number of schools	5391	5391	5390	5390
F Statistics	3.322	3.322	3.473	3.473
		grade 6 - 2010-2012-2013		
TV watching hours	2.326**	3.643***	2.052***	2.895***
	(0.918)	(1.228)	(0.781)	(0.938)
foreignborn × TV watching hours	-0.292***	-0.382***	-0.408***	-0.430***
	(0.064)	(0.086)	(0.055)	(0.066)
Observations	694743	694743	693856	693856
Number of schools	4382	4382	4382	4382
F Statistics	4.313	4.313	4.428	4.428
		grade 6 - 2010-2012-2013		
TV watching hours	-0.946*	-1.362**	1.459**	-0.202
	(0.539)	(0.614)	(0.605)	(0.387)
nocollege × TV watching hours	-0.158***	-0.149***	-0.218***	-0.168***
	(0.014)	(0.016)	(0.016)	(0.010)
Observations	694743	694743	693856	693856
Number of schools	4382	4382	4382	4382
F Statistics	4.008	4.008	3.82	3.82
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), whether external control during test, number of books at home, parental education and occupation, ECEC and preprimary attendance, weekly hours of school attendance, share of educated and high-class parents in the school, share of female/native/repeaters at school level, (log of) school size + years/grade and province fixed effects.

6 Conclusion

This study investigates the effects of the transition from analog to Digital Terrestrial Television (DTT) on academic performance among Italian students, utilizing data from INVALSI assessments conducted between 2009 and 2012. The staggered regional rollout of DTT across Italy serves as a natural experiment, enabling a robust analysis of how increased access to television channels influences student outcomes. Employing a combination of Difference-in-Differences (DiD) and Instrumental Variable (IV) methodologies, the study provides causal estimates of television exposure on literacy and numeracy test scores. The findings consistently indicate a negative impact of expanded television access on academic performance, with the effects being particularly pronounced in numeracy; however, the magnitude of the effect is contained within one-tenth of a standard deviation. Across multiple grade levels, the increased availability of digital channels is associated with declines in test scores. However, the impact of DTT is not homogeneous across all student groups. Notably, foreign-born students and children from families with lower educational attainment of corresponding parents appear to benefit from increased television access, particularly in literacy. Television may be an educational resource for these students, providing exposure to language and cultural content that might otherwise be unavailable in their home environments. This "compensatory effect" highlights the potential role of television in reducing educational disparities for disadvantaged populations. In contrast, native students and those from more educated families experience a more pronounced negative impact, indicating a "substitution effect" where television viewing displaces time that could have been devoted to more academically oriented activities. This effect is especially significant for female students and those from higher socio-economic backgrounds. An analysis of time-use data offers further insights into these dynamics. The transition to digital television is associated with reduced time spent on homework and reading, particularly among younger students in Grade 5. In Grade 6, the effect is less pronounced, likely due to differences in school structure and greater autonomy in time management. The study also examines the relationship between self-reported television viewing hours and test scores. While Ordinary Least Squares (OLS) regression initially suggests a positive association between television viewing and academic performance, this relationship appears to be confounded by unobserved factors such as student ability. When an Instrumental Variable approach is employed, using the timing of the digital switchover as an instrument, a negative causal relationship emerges, particularly in numeracy for younger students. These results have significant implications for policymakers and educators. While the digital transition democratized access to a broader range of media content, it also exacerbated educational inequalities. Although some disadvantaged students may benefit from increased television access, the overall negative impact on academic performance, especially among higher-achieving students, underscores the need for targeted interventions.

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A Appendix

Table A1. Available channels in Italy 2010-2012

Name of the Channel	Owner	Analog	Digital	Content	Avl.in 2010	Avl. in 2011	Avl. in 2012
Rai 1	RAI	X		General	X	X	X
Rai 2	RAI	X		General	X	X	X
Rai 3	RAI	X		General	X	X	X
Rai 4	RAI		X	Children	X	X	X
Rai 5	RAI		X	Culture	X	X	X
Rai Sport 1	RAI		X	Sport	X	X	X
Rai Sport 2	RAI		X	Sport	X	X	X
Rai News 24	RAI		X	News	X	X	X
Rai Scuola	RAI		X	Culture	X	X	X
Rai Storia	RAI		X	Culture	X	X	X
Rai gulp (also +1)	RAI		X	Children	X	X	X
Rai movie	RAI		X	Movie	X	X	X
Rai premium	RAI		X	General	X	X	X
Rai yoyo	RAI		X	Children	X	X	X
Rai HD	RAI		X	General	X		
Canale 5 (also +1 and HD)	Mediaset	X	X	General	X	X	X
Italia 1 (also +1 and HD)	Mediaset	X	X	General	X	X	X
Rete 4 (also +1)	Mediaset	X	X	General	X	X	X
Boing (also +1)	Mediaset		X	Children	X	X	X
Iris	Mediaset		X	Culture/ Movie	X	X	X
La5	Mediaset		X	Woman's	X	X	X
Mediaset Extra	Mediaset		X	General	X	X	X
ME	Mediaset		X	Shopping	X		
TG Mediaset	Mediaset		X	News	X		
La7	Telecom Italia Media	X		General	X	X	X
La7D	Telecom Italia Media		X	Woman's	X	X	X
MTV	Telecom Italia Media	X		Music	X	X	X
MTV Music	Telecom Italia Media		X	Music	X	X	X
Odeon 24	Profit Group	X		General	X	X	
Canale Italia	Canale Italia	X		General	X	X	
7Gold	Italia 7 Gold			General	X	X	
TG Norba 24	Telenorba		X	News	X		
Cielo	Sky Italia		X	General	X	X	X
Real Time (also +1)	Discovery		X	Lifestyle	X	X	X
Nuvolari	SitCom		X	Cars	X	X	
K2	Switchover		X	Children	X	X	X
Frisbee	Switchover		X	Children	X	X	X

Name of the Channel	Owner	Analog	Digital	Content	Avl. in 2010	Avl. in 2011	Avl. in 2012
Poker Italia 24	Magnolia		X	Sport	X		
Rtl 102.5	RTL		X	Music	X		
Coming Soon	Anica		X	Movie	X	X	X
Class News	Class		X	News	X	X	X
SportItalia	Interactive		X	Sport	X	X	X
SportItalia2	Interactive		X	Sport	X	X	X
SportItalia24	Interactive		X	Sport	X	X	X
QVC	QVC		X	Shopping	X		
Wedding TV	Wedding tv		X	Woman's		X	
Deejay TV	Gr. Editoriale L'Espresso		X	Music		X	X
DMAX	Discovery		X	Man's		X	X
Italia 2 Mediaset	Mediaset		X	Children		X	X
Repubblica TV	Gr.Editoriale L'Espresso		X	News		X	X
TG Norba 24	Telenorba		X	News		X	
TgCom24	Mediaset		X	News		X	X
Focus	Switchover/ Discovery		X	Culture			X
Giallo	Switchover/ Discovery		X	Culture			X

Source: AGCOM, Relazione annuale, various issues. Digital includes DTT, satellite and IPTV. HD denotes that the channel was available in both low and high-definition formats, whereas +1 indicates the presence of an additional channel broadcasting the same content with a one-hour delay

Table A2. DiD estimate (excluding provinces already treated in 2009-10)

	numeracy	Rasch numeracy	literacy	Rasch literacy
		Grade 2		
treatment	-0.099***	-0.138***	-0.029***	-0.064***
	(0.011)	(0.015)	(0.009)	(0.012)
Observations	1369197	1369197	1374241	1374241
Adjusted R^2	0.085	0.088	0.082	0.079
Number of schools	6025	6025	6023	6023
		Grade 5		
treatment	-0.073***	-0.094***	-0.091***	-0.096***
	(0.011)	(0.013)	(0.009)	(0.010)
Observations	1356308	1356308	1364787	1364787
Adjusted R^2	0.074	0.071	0.101	0.160
Number of schools	6031	6031	6027	6027
		Grade 6		
treatment	-0.017**	0.017*	-0.026***	-0.005
	(0.008)	(0.008)	(0.008)	(0.009)
Observations	1393991	1393991	1396582	1396582
Adjusted R^2	0.131	0.127	0.180	0.164
Number of schools	5018	5018	5018	5018
		Grade 8		
treatment	-0.095***	-0.085***	0.007	0.003
	(0.010)	(0.010)	(0.008)	(0.008)
Observations	1450953	1450953	1452584	1452584
Adjusted R^2	0.069	0.066	0.113	0.099
Number of schools	5012	5012	5012	5012
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), share of female/native/repeaters at school level, (log of) school size, whether external control during test + years and province fixed effects - Further controls for grades 2-5-6 are parental education and occupation, ECEC and pre-primary attendance, weekly hours of school attendance, share of educated and high class parents in the school.

Table A3. DiD estimate (including provinces already treated in 2009-10)

	numeracy	Rasch numeracy	literacy	Rasch literacy
		Grade 2		
treatment	-0.048***	-0.068***	-0.015*	-0.031***
	(0.009)	(0.013)	(0.008)	(0.010)
Observations	1907839	1907839	1914351	1914351
Adjusted R^2	0.079	0.083	0.074	0.071
Number of schools	8874	8874	8869	8869
		Grade 5		
treatment	-0.038***	-0.046***	-0.056***	-0.056***
	(0.009)	(0.011)	(0.007)	(0.008)
Observations	1899116	1899116	1910864	1910864
Adjusted R^2	0.067	0.065	0.090	0.149
Number of schools	8867	8867	8861	8861
		Grade 6		
treatment	0.002	0.021***	-0.017***	-0.000
	(0.007)	(0.007)	(0.006)	(0.007)
Observations	1950341	1950341	1954947	1954947
Adjusted R^2	0.128	0.123	0.169	0.155
Number of schools	7095	7095	7095	7095
		Grade 8		
treatment	-0.086***	-0.074***	-0.027***	-0.023***
	(0.009)	(0.008)	(0.007)	(0.007)
Observations	2059197	2059197	2061923	2061923
Adjusted R^2	0.064	0.062	0.105	0.093
Number of schools	7087	7087	7087	7087
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), share of female/native/repeaters at school level, (log of) school size, whether external control during test + years and province fixed effects - Further controls for grades 2-5-6 are parental education and occupation, ECEC and pre-primary attendance, weekly hours of school attendance, share of educated and high class parents in the school.

Table A4. DiD estimate (including provinces already treated in 2009-10) – variable treatment intensity based on time distance

	numeracy	Rasch numeracy	literacy	Rasch literacy
		Grade 2		
distance	-0.000	-0.000	-0.000**	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1907839	1907839	1914351	1914351
Adjusted R^2	0.079	0.083	0.074	0.071
Number of schools	8874	8874	8869	8869
		Grade 5		
distance	-0.000	-0.000	-0.000**	0.015***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1898861	1898861	1910612	1910612
Adjusted R^2	0.067	0.065	0.090	0.148
Number of schools	8867	8867	8861	8861
		Grade 6		
distance	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1950341	1950341	1954947	1954947
Adjusted R^2	0.128	0.123	0.169	0.155
Number of schools	7095	7095	7095	7095
		Grade 8		
distance	-0.001***	-0.001***	-0.002***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2058688	2058688	2061414	2061414
Adjusted R^2	0.063	0.061	0.105	0.093
Number of schools	7087	7087	7087	7087
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), the share of female/native/repeaters at school level, (log of) school size, whether external control during test + years and province fixed effects - Further controls for grades 2-5-6 are parental education and occupation, ECEC and pre-primary attendance, weekly hours of school attendance, the share of educated and high-class parents in the school.

Table A5. Time use and digital reform (excluding provinces already treated in 2009-10) – variable treatment intensity based on time distance

	watching TV	playing games on PC	reading books	with friends	helping at home
	(1)	(2)	(3)	(4)	(5)
			grade 5 - 2010-2012-2013		
distance	-0.001***	-0.002***	-0.001***	-0.000***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1004504	1004326	1006173	1001673	1004110
Adjusted R^2	0.018	0.102	0.068	0.013	0.050
Number of schools	6026	6026	6027	6027	6027
			grade 6 - 2010-2012-2013		
distance	-0.001***	-0.002***	-0.001***	0.002***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1046692	1046766	1046873	1044689	1045549
Adjusted R^2	0.023	0.097	0.081	0.023	0.047
Number of schools	5012	5012	5011	5012	5012
			grade 5 in 2012 - grade 6 in 2013		
distance	0.010***	0.004***	-0.011***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	675135	675092	675284	673614	674686
Adjusted R^2	0.024	0.102	0.080	0.014	0.049
Number of schools	6545	6545	6545	6545	6545
Prov FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), whether external control during test, number of books at home, parental education and occupation, ECEC and preprimary attendance, weekly hours of school attendance, share of educated and high-class parents in the school, share of female/native/repeaters at school level, (log of) school size + years/grade and province fixed effects.

Table A6. Student achievements and TV watching hours (excluding provinces already treated in 2009-10) – OLS – full model – grade 5

	numeracy	Rasch numeracy	literacy	Rasch literacy
	grade 5 - 2010-2012-2013			
TV watching hours	0.021***	0.022***	0.017***	0.016***
	(0.002)	(0.002)	(0.002)	(0.002)
female	-0.144***	-0.165***	0.108***	0.106***
	(0.003)	(0.003)	(0.002)	(0.002)
age	-0.002	0.001	-0.038***	-0.017***
	(0.004)	(0.004)	(0.004)	(0.004)
born in Italy	0.147***	0.156***	0.260***	0.237***
	(0.006)	(0.007)	(0.006)	(0.006)
11 -25 books	0.232***	0.254***	0.306***	0.270***
	(0.005)	(0.006)	(0.005)	(0.005)
25 - 100 books	0.395***	0.435***	0.465***	0.437***
	(0.006)	(0.007)	(0.005)	(0.005)
100 -200 books	0.487***	0.544***	0.555***	0.548***
	(0.006)	(0.007)	(0.006)	(0.006)
More than 200 books	0.482***	0.545***	0.561***	0.571***
	(0.007)	(0.008)	(0.007)	(0.007)
upper secondary	0.192***	0.212***	0.230***	0.224***
	(0.003)	(0.004)	(0.003)	(0.003)
college	0.339***	0.389***	0.376***	0.390***
	(0.004)	(0.005)	(0.004)	(0.005)
service class	0.109***	0.120***	0.102***	0.097***
	(0.004)	(0.005)	(0.004)	(0.004)
high class	0.119***	0.131***	0.123***	0.121***
	(0.004)	(0.005)	(0.004)	(0.004)
attended early childcare	-0.005	-0.006	-0.022***	-0.025***
	(0.005)	(0.007)	(0.004)	(0.005)
attended pre-primary	0.023**	0.021	0.042***	0.034***
	(0.010)	(0.013)	(0.008)	(0.009)
external control	-0.220***	-0.265***	-0.170***	-0.190***
	(0.011)	(0.013)	(0.009)	(0.009)
father or mother born abroad	-0.184***	-0.198***	-0.300***	-0.271***
	(0.006)	(0.006)	(0.006)	(0.006)
sh.native in school	-0.171***	-0.187***	-0.248***	-0.231***
	(0.039)	(0.050)	(0.028)	(0.032)
sh.repeaters in school	-0.324***	-0.390***	-0.356***	-0.343***
	(0.079)	(0.104)	(0.058)	(0.066)
sh.female in school	0.128*	0.154*	0.104**	0.105*
	(0.066)	(0.084)	(0.051)	(0.060)
sh.college ed.parents	-0.094***	-0.099***	-0.105***	-0.098***
	(0.024)	(0.030)	(0.018)	(0.021)
sh.high class parents	-0.069***	-0.084***	-0.071***	-0.084***
	(0.023)	(0.029)	(0.018)	(0.021)
sc.size	0.008	0.006	0.017**	0.009
	(0.009)	(0.012)	(0.007)	(0.008)
Observations	665927	665927	647905	647905
Adjusted R^2	0.101	0.098	0.125	0.189
Number of schools	5392	5392	5391	5391
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1

Table A7. Student achievements and TV watching hours (excluding provinces already treated in 2009-10) – OLS – full model – grade 6

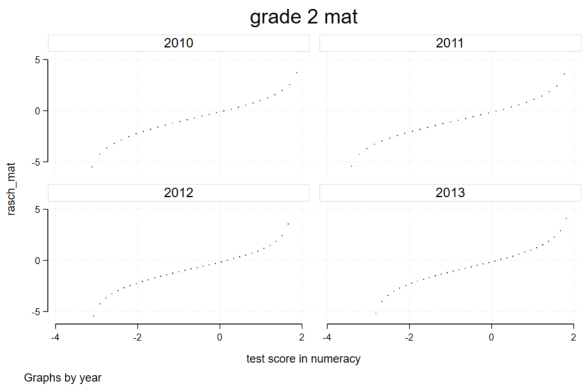
	numeracy	Rasch numeracy	literacy	Rasch literacy
	grade 6 - 2010-2012-2013			
TV watching hours	0.013***	0.012***	0.023***	0.019***
	(0.002)	(0.002)	(0.002)	(0.001)
female	-0.151***	-0.153***	0.107***	0.093***
	(0.003)	(0.003)	(0.002)	(0.002)
age	-0.139***	-0.141***	-0.183***	-0.152***
	(0.003)	(0.004)	(0.004)	(0.003)
born in Italy	0.138***	0.136***	0.300***	0.257***
	(0.005)	(0.005)	(0.006)	(0.005)
11 -25 books	0.220***	0.224***	0.281***	0.238***
	(0.004)	(0.004)	(0.004)	(0.004)
25 - 100 books	0.418***	0.418***	0.477***	0.412***
	(0.005)	(0.005)	(0.005)	(0.004)
100 -200 books	0.544***	0.544***	0.604***	0.535***
	(0.005)	(0.005)	(0.005)	(0.005)
More than 200 books	0.612***	0.617***	0.669***	0.609***
	(0.006)	(0.006)	(0.006)	(0.005)
upper secondary	0.238***	0.235***	0.261***	0.228***
	(0.003)	(0.003)	(0.003)	(0.003)
college	0.395***	0.396***	0.413***	0.379***
	(0.005)	(0.005)	(0.004)	(0.004)
service class	0.123***	0.122***	0.111***	0.097***
	(0.004)	(0.004)	(0.003)	(0.003)
high class	0.138***	0.136***	0.142***	0.125***
	(0.004)	(0.004)	(0.004)	(0.003)
father or mother born abroad	-0.174***	-0.171***	-0.274***	-0.237***
	(0.005)	(0.005)	(0.005)	(0.005)
attended early childcare	-0.020***	-0.020***	-0.031***	-0.027***
	(0.004)	(0.004)	(0.004)	(0.003)
attended pre-primary	0.012*	0.012*	0.020***	0.016***
	(0.007)	(0.007)	(0.006)	(0.005)
external control	-0.063***	-0.062***	-0.046***	-0.040***
	(0.008)	(0.008)	(0.007)	(0.006)
sh.native in school	-0.126***	-0.122***	-0.255***	-0.220***
	(0.023)	(0.024)	(0.020)	(0.018)
sh.repeaters in school	-0.547***	-0.550***	-0.798***	-0.696***
	(0.057)	(0.057)	(0.050)	(0.045)
sh.female in school	-0.045	-0.044	-0.058	-0.049
	(0.049)	(0.050)	(0.041)	(0.037)
sh.college ed.parents	-0.066***	-0.067***	-0.068***	-0.060***
	(0.018)	(0.019)	(0.015)	(0.014)
sh.high class parents	-0.101***	-0.099***	-0.090***	-0.080***
	(0.017)	(0.017)	(0.014)	(0.013)
sc.size	0.053***	0.053***	0.052***	0.046***
	(0.006)	(0.006)	(0.005)	(0.005)
Observations	704025	704025	703129	703129
Adjusted R^2	0.145	0.143	0.200	0.196
Number of schools	4382	4382	4382	4382
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1

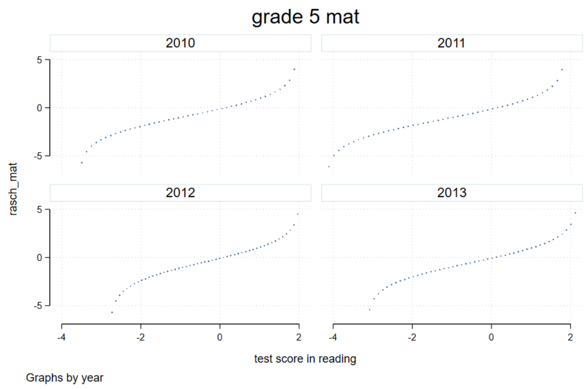
Table A8. Student achievements and TV watching hours (excluding provinces already treated in 2009-10) - IV= weekly hours of schooling

	(1) numeracy	(2) Rasch numeracy	(3) literacy	(4) Rasch literacy
		grade 5 - 2010-2012-2013		
TV watching hours	-1.043**	-1.340**	2.130***	2.126***
	(0.437)	(0.530)	(0.433)	(0.456)
Observations	967757	967757	940226	940226
Number of schools	6010	6010	6006	6006
F Statistics	48.17	48.17	50.77	50.77
First stage	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
		grade 6 - 2010-2012-2013		
TV watching hours	-5.296*	-5.141*	-3.085	-3.301*
	(3.135)	(3.045)	(1.881)	(1.936)
Observations	989685	989685	989610	989610
Number of schools	4998	4998	4999	4999
F Statistics	3.26	3.26	3.405	3.405
First stage	-0.001*	-0.001*	-0.001*	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)
Prov FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

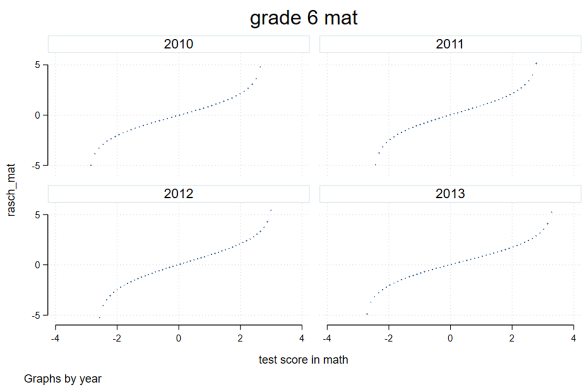
Robust standard errors in brackets, clustered at school level - *** p<0.01, ** p<0.05, * p<0.1 - Controls include gender, age, citizenship (of the student and parents), number of books at home, parental education and occupation, ECEC and pre-primary attendance, weekly hours of school attendance, share of educated and high-class parents in the school, share of female/native/repeaters at school level, (log of) school size, whether external control during test + years/grade and province fixed effects.



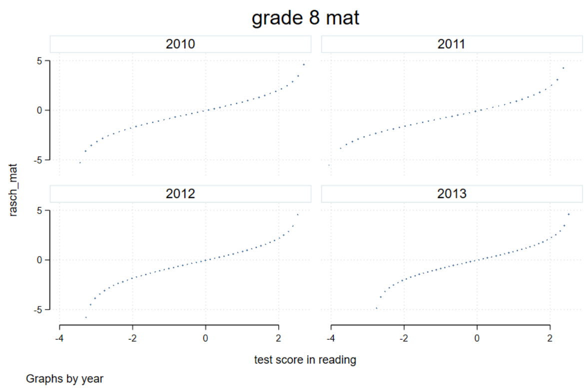
(c) g2



(d) g5



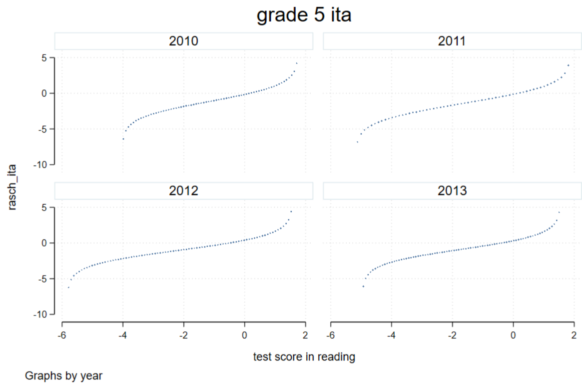
(e) g6



(f) g8

Figure A1. Numeracy

(a) g2

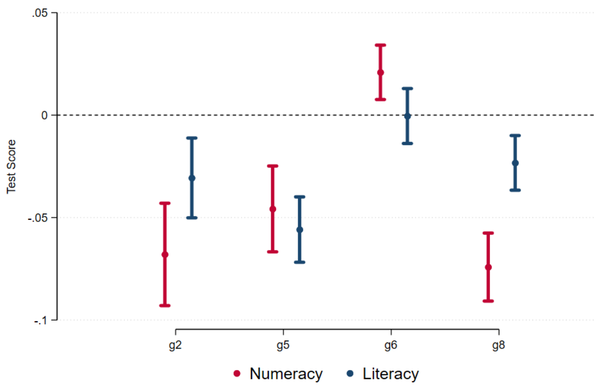


(b) g5

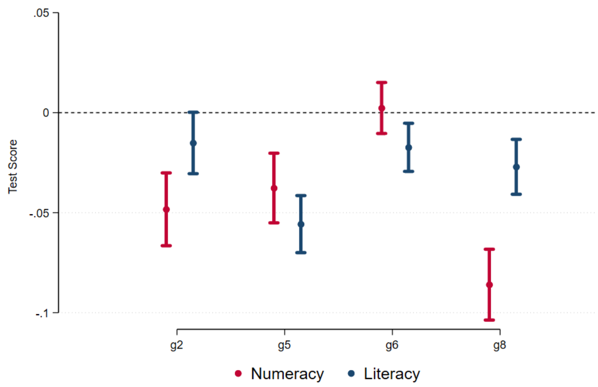
(c) g6

(d) g8

Figure A2. Literacy



(a) Rasch

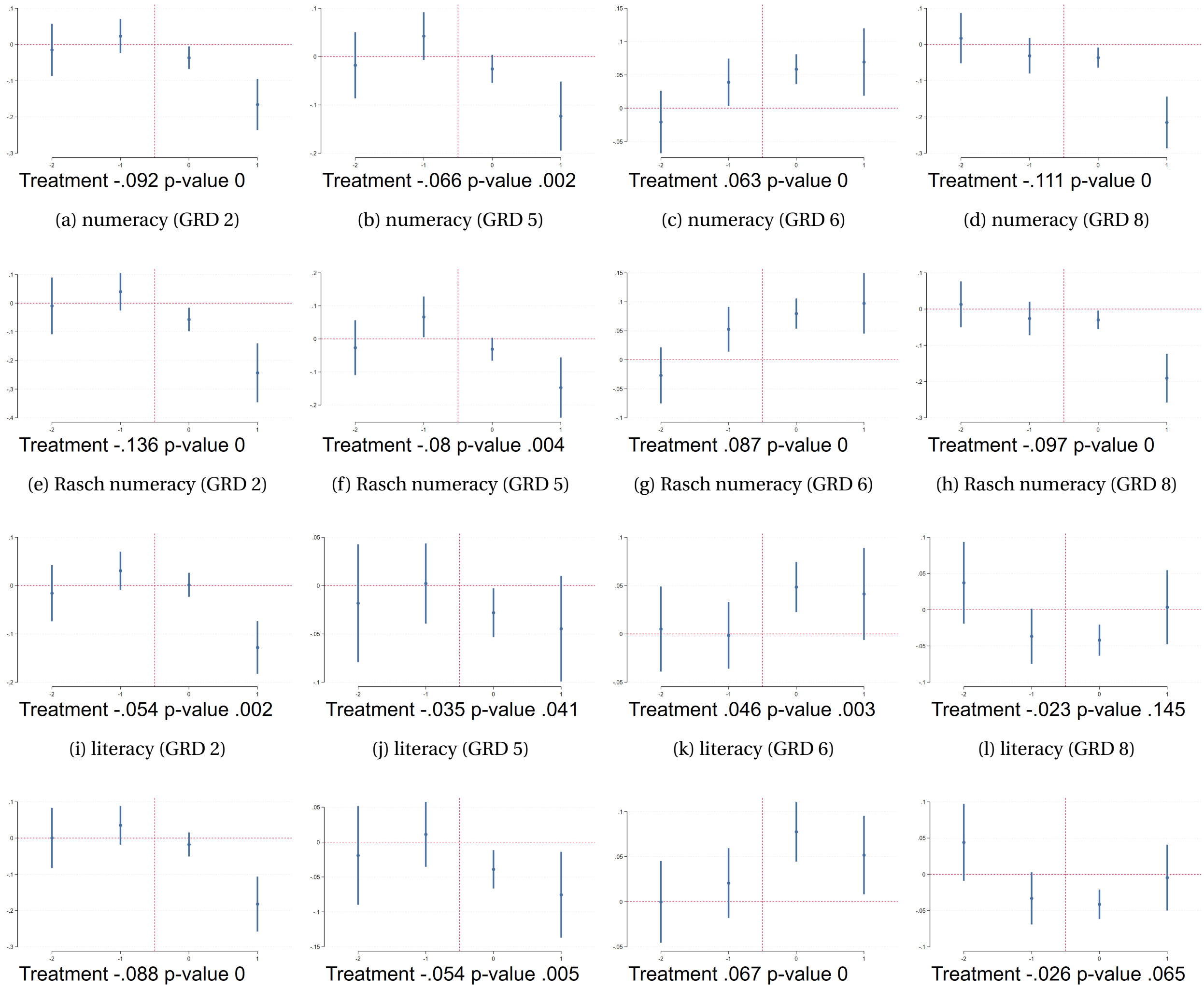


(b) Stardized test score

Figure A3. DiD estimate

A.1 Treatment effect heterogeneity

Figure A4. Regression adjustment estimates



(a) numeracy (GRD 2) (b) numeracy (GRD 5) (c) numeracy (GRD 6) (d) numeracy (GRD 8)

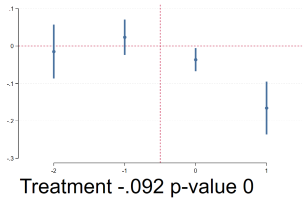
(e) Rasch numeracy (GRD 2) (f) Rasch numeracy (GRD 5) (g) Rasch numeracy (GRD 6) (h) Rasch numeracy (GRD 8)

(i) literacy (GRD 2) (j) literacy (GRD 5) (k) literacy (GRD 6) (l) literacy (GRD 8)

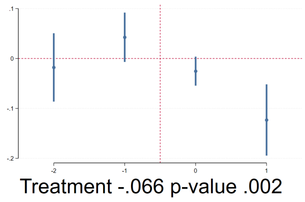
(m) Rasch literacy (GRD 2) (n) Rasch literacy (GRD 5) (o) Rasch literacy (GRD 6) (p) Rasch literacy (GRD 8)

Figure A5. This figure presents the dynamic impact of the digital television transition on standardized test scores, assessing the presence of pre-trends and accounting for treatment effect heterogeneity. The displayed estimates represent the regression adjustment estimator for the treatment effect associated with the number of years preceding or following the digital transition in the student's province of residence at the time of the exam, along with their corresponding 95% confidence intervals. The dependent variable varies across panels: Panel (a) displays standardized numeracy scores; Panel (b) presents Rasch-transformed numeracy scores; Panel (c) shows standardized literacy scores; and Panel (d) exhibits Rasch-transformed literacy scores. The aggregate treatment effect and its associated p-value are reported in the figure footnote of each figure.

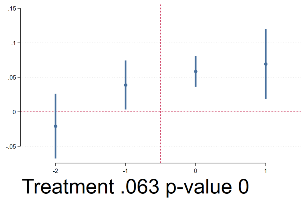
Figure A6. Augmented inverse probability weighting estimates



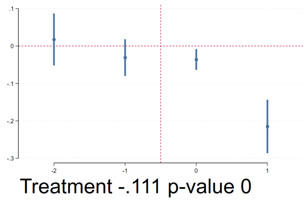
(a) numeracy (GRD 2)



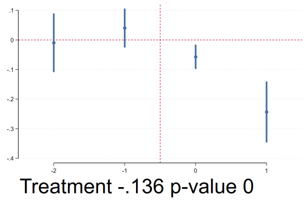
(b) numeracy (GRD 5)



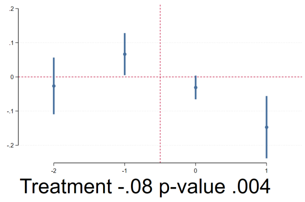
(c) numeracy (GRD 6)



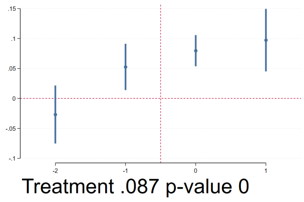
(d) numeracy (GRD 8)



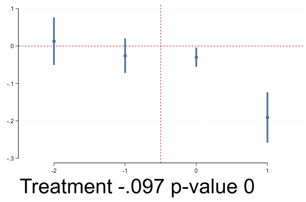
(e) Rasch numeracy (GRD 2)



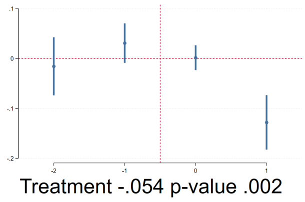
(f) Rasch numeracy (GRD 5)



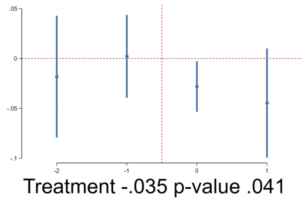
(g) Rasch numeracy (GRD 6)



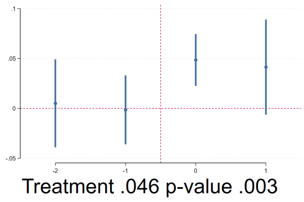
(h) Rasch numeracy (GRD 8)



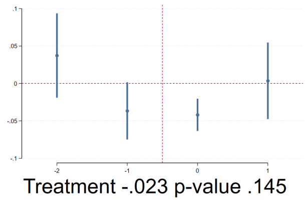
(i) literacy (GRD 2)



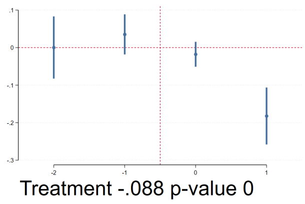
(j) literacy (GRD 5)



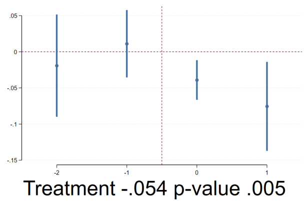
(k) literacy (GRD 6)



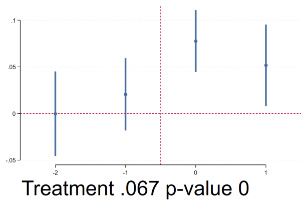
(l) literacy (GRD 8)



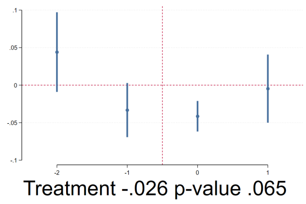
(m) Rasch literacy (GRD 2)



(n) Rasch literacy (GRD 5)



(o) Rasch literacy (GRD 6)



(p) Rasch literacy (GRD 8)

Figure A7. This figure presents the dynamic impact of the digital television transition on standardized test scores, assessing the presence of pre-trends and accounting for treatment effect heterogeneity. The displayed estimates represent the augmented inverse probability weighting estimator for the treatment effect associated with the number of years preceding or following the digital transition in the student's province of residence at the time of the exam, along with their corresponding 95% confidence intervals. The dependent variable varies across panels: Panel (a) displays standardized numeracy scores; Panel (b) presents Rasch-transformed numeracy scores; Panel (c) shows standardized literacy scores; and Panel (d) exhibits Rasch-transformed literacy scores. The aggregate treatment effect and its associated p-value are reported in the figure footnote of each figure.