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More Channels, Lower Scores: Entertainment Television and Student Achievement*

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Abstract

We study the effects of expanded entertainment television on children's academic performance leveraging the staggered transition from analog to digital TV across Italian provinces between 2008 and 2012, which greatly increased children's entertainment content, and administrative data on standardized test scores for entire cohorts of primary and middle school students. Availability of digital TV reduced literacy and math performance by 0.08 and 0.12 standard deviations, respectively, implying effects of 0.20 and 0.30 standard deviations among children who acquired access to digital TV along the transition. Effects are larger among younger children and among students attending school only in the morning.

Keywords: Television, Schooling, Standardized test scores

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1 Introduction

Television has long served as a nanny for generations of children, raising persistent concerns about its effects on learning and cognitive development (Anderson and Subrahmanyam, 2017; Christakis et al., 2004). The expansion of cable television in the 1980s and 1990s, followed by the transition to digital broadcasting in the 2000s, substantially increased children's exposure to screen-based entertainment. While recent attention has shifted toward smartphones and social media, television remains a central component of children's media consumption. Time-use evidence shows that, even in the digital era, television accounts for a large share of children's total screen time, often exceeding that of newer digital devices–especially at younger ages. Based on data from Rideout and Robb (2025), children in the United States aged 0–8 spend on average about two and a half hours per day on screen media, 60% of which is devoted to television, compared to 26% for video games and only 6% for social networks and video chats. Even at older ages (8–12), television remains the dominant form of screen use, accounting for more than half of total screen time (53%; see Rideout and Robb, 2019). Understanding the impact of exposure to television content therefore remains highly relevant.

We study the effects of a large increase in television content targeted at children on their academic performance, leveraging the transition from analog to digital terrestrial television (DTV) in Italy between 2008 and 2012. Before the transition, television supply in Italy was highly concentrated, with only seven national channels broadcast on analog signal. Importantly, all these channels offered generalist programming and limited content specifically targeted at children, which was mostly confined to a few hours on a single private channel (*Italia 1*). Although digital channels were already available prior to 2008, their diffusion remained limited because access required a digital decoder, which relatively few households had adopted. This, together with persistence in viewing habits, constrained both audience demand and the incentives for entry of new channels into the digital market (Adda and Ottaviani, 2005).

The situation changed dramatically following a 2007 EU directive mandating the switch-off of the analog signal. The transition was implemented gradually, with the analog signal progressively switched off across 16 macro-areas between 2008 and 2012. The switch-off effectively required households to adopt digital reception technology in order to continue watching television, leading to a sharp increase in the diffusion of digital decoders. As we document below, the share of households owning a decoder doubled–from about 40 to 80 percent–around the transition. This, in turn, triggered a rapid expansion in the supply of television content. Digital broadcasting introduced more than one hundred additional channels, on top of the seven national channels previously available under analog broadcasting. Among these, more than ten targeted children specifically, offering almost exclusively entertainment content and leading to a substantial shift in children's viewing patterns.

We exploit the staggered timing of the analog switch-off across areas to estimate the causal effect of this expansion in children's television content on academic outcomes. Using administrative data on standardized test scores in literacy and math for the universe of primary and middle school students over four academic years – covering more than 8 million students across 11,000 schools –we compare outcomes for cohorts exposed to the transition at different points in time.

We find that the expansion of digital television leads to a significant decline in students' academic performance. Two years after the transition, test scores decrease by approximately 0.08 standard deviations in literacy and 0.12 standard deviations in math. Rescaling these ("intention-to-treat") estimates of potential exposure to DTV by the increase in actual DTV access induced by the switchoff – measured by the 40-percentage point increase in decoder ownership – yields effects of approximately -0.20 and -0.30 standard deviations in literacy and math, respectively, for children in households that transitioned to digital television. These estimates remain statistically significant under a stringent permutation-based inference procedure that compares the estimated effects at the true transition dates to the distribution obtained by randomly reassigning transition timing across macro-areas; the probability of observing effects of similar (or greater) magnitude under the null is approximately 1%. Moreover, estimates remain virtually identical when sequentially dropping each of the macro-areas contributing to the identifying variation in the staggered difference-in-differences estimator.

Heterogeneity analysis sheds light on the underlying mechanisms. The main effects are concentrated among younger students in primary school, while they are substantially smaller for middle school pupils, consistent with greater susceptibility to distraction and more limited ability to regulate media consumption at younger ages. Negative effects are stronger for students attending morning-only schools – over two thirds of the sample – than for those in full-day schools, consistent with a role for time substitution between television viewing and educational activities. These mechanisms appear to operate similarly across students of different gender and parental background. For students with a migration background, however, the decline in literacy scores is attenuated, suggesting that exposure to television may partly facilitate language acquisition, although this mitigating effect is incomplete and does not extend to math performance.

Our paper contributes to the literature on media exposure and human capital formation. Earlier contributions on the United States paint a relatively benign—and in some cases positive—picture of television exposure. Using the historical rollout of television across local markets, Gentzkow and Shapiro (2008) find no evidence that preschool television exposure harmed later test scores; if anything, their preferred estimates are slightly positive, particularly for reading, verbal, and general knowledge outcomes. Likewise, Kearney and Levine (2019) show that exposure to *Sesame Street* improved subsequent school performance, especially among disadvantaged children.[1] An important difference with our setting is that these studies concern either general early television in a very different media environment or explicitly educational programming.

More recent work studies the transition from analogue to digital television in Europe. Closest to our setting, Nieto Castro (2025) shows *positive* effects of the switchover on the test scores of 11-year-old pupils in the UK, driven primarily by economically disadvantaged students and low achievers. The paper argues that increased television viewing displaced social interactions associated with risky behaviors such as alcohol consumption, particularly among disadvantaged children.

By contrast, extending the analysis to different grades, we uncover *negative* effects concentrated among younger primary school children, while effects for middle school students—who

[1] See also the early evaluations of *Sesame Street* by Ball and Bogatz (1970, 1971), which documented improvements in cognitive and school readiness outcomes among preschool children exposed to the program.

are similar in age to the pupils studied by Nieto Castro (2025)—are much smaller and often statistically insignificant. This heterogeneity by age is consistent with extensive evidence that younger children are more susceptible to shocks affecting cognitive development and learning because self-regulation and executive control are still developing in childhood (see, e.g. Cunha and Heckman, 2007). In addition, the change in television content induced by the transition may have differed substantially across the two settings. Unlike the UK case, where the transition expanded general television access, the Italian transition generated a particularly large increase in content specifically targeted at children. The negative effects may also have been reinforced by the institutional structure of Italian primary schools, where the majority of students attend only in the morning, leaving more discretionary time for television viewing and therefore stronger time-substitution effects.

Also consistent with negative effects of entertainment television, Durante et al. (2019) study the staggered expansion of Mediaset's commercial television in Italy in the early 1980s and document long-run negative effects on cognitive skills among individuals exposed during childhood. Similarly, Bai et al. (2026) show that increased exposure to entertainment television during adolescence in China—induced by a large-scale television subsidy program in rural areas—reduces cognitive performance and educational attainment, with persistent effects on individual behavior. However, both of these papers focus primarily on political attitudes and preferences as their main outcomes, using cognitive skills and educational attainment mainly as mechanisms to interpret those effects. By contrast, our paper takes cognitive and educational performance as the primary outcomes of interest. Moreover, we study a substantially larger shock to children's media environment. While Mediaset was a precursor that introduced a limited amount of children's entertainment programming on a single channel (*Italia 1*), the transition to digital television generated a much broader expansion in content supply, including many channels entirely devoted to children's entertainment.

Complementary evidence from the medical and developmental literature also points to adverse effects of early television exposure on cognitive development and academic performance (Zimmerman and Christakis, 2005; Hancox et al., 2005; Pagani et al., 2010). However, these studies either focus on long-run outcomes or do not provide causal evidence based on large-scale variation in exposure to entertainment content. More broadly, our results speak to ongoing debates about the role of media environments in shaping children's development.

Finally, our paper complements previous evidence on the effects of the DTV transition in Italy on other outcomes, namely voting behavior (Barone et al., 2015), crime perceptions (Mastrorocco and Minale, 2018), and fertility (Caria, 2025). While we focus on a different outcome, these studies support the interpretation of the DTV transition as a credible source of exogenous variation in media exposure. Our empirical approach also incorporates recent methodological advances in the econometric analysis of staggered treatment designs (Callaway and Sant'Anna, 2021; De Chaisemartin and d'Haultfoeuille, 2023).

2 The Digital TV Transition and Research Design

The switchoff of analog television. Until 2007, the Italian TV market was highly concentrated among seven national channels transmitted on analog signal: three public channels operated by *RAI* (*Rai 1*, *Rai 2*, and *Rai 3*); three private channels owned by the Berlusconi family through the Mediaset group (*Rete 4*, *Canale 5*, and *Italia 1*); and a seventh private channel (*LA7*). This oligopolistic structure implied a relatively limited supply of television content. In particular, programming targeted specifically at children was largely confined to a small number of hours in the mid-afternoon, mainly on Mediaset channels.[2]

The 2007 EU directive, transposed into Italian legislation on November 22 of the same year through Law 222/2007, mandated the switch-off of the analog signal, effectively requiring households to acquire a digital decoder to continue accessing television. To facilitate the transition, the government fully subsidized decoder purchases – whose cost was in any case modest (below €200), so some households had already adopted decoders prior to the switch-off. Nonetheless, the latter generated a sharp increase in adoption, as we document next.

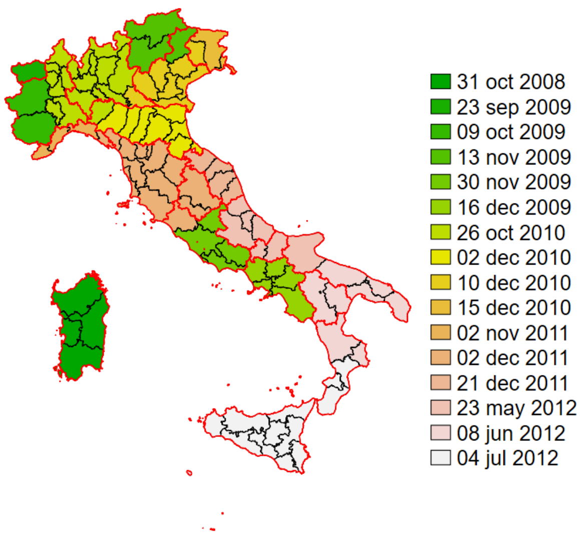
Crucially for our identification strategy, the switch-off was staggered across Italian provinces between 2008 and 2012. The map in Panel A of Figure 1 shows the timing of the transition.

[2]Since its entry into the national market in the 1980s and 1990s, Mediaset traditionally devoted more airtime to entertainment programming, including cartoons and TV series for children, than public *RAI*, although the programming strategies of public and private broadcasters have converged over time (Durante et al., 2019; Barra et al., 2024).

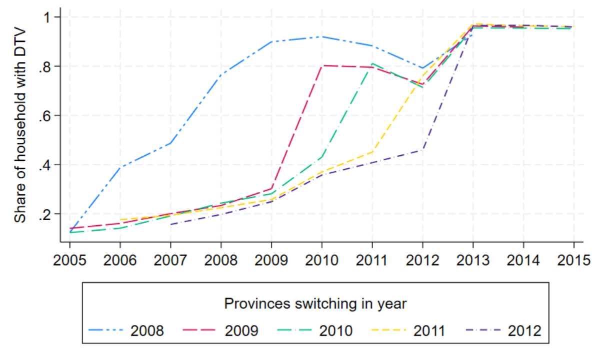
There is substantial variation–up to four years separate early and late adopters–and areas switching on the same date correspond to aggregations of provinces that largely, though not perfectly, overlap with groups of regions.[3]

Figure 1: The transition to DTV

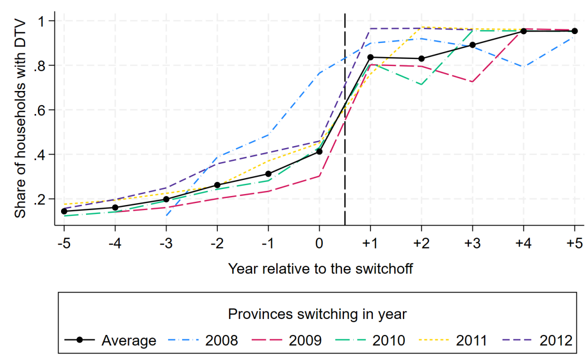
Panel A. Transition dates across areas



Panel B. Access to DTV, by year of transition



Panel C. Access to DTV, by year of transition (re-centered)



Notes: Panel A maps the timing of the transition from analog to digital terrestrial television (DTV) across Italian provinces between 2008 and 2012. Panel B reports the share of households with school-age children owning a digital decoder in the years before and after the switch-off, separately by calendar year of transition. Panel C re-centers the series in Panel B around the switch-off year ($t = 0$) and reports the average across all transition cohorts. Decoder ownership is measured using the annual ISTAT "Aspects of Daily Life" survey.

The remaining panels of Figure 1 document the expansion in access to DTV channels around the transition period. The time-use survey conducted annually by the Italian Na-

[3]For instance, the region of Sardinia was the first to switch, in October 2008, followed by Valle d'Aosta in September 2009. The third group, in October 2009, comprised the western provinces of Piedmont (Turin and Cuneo), while the remaining provinces of the same region switched only one year later. The fourth area, in November 2009, included the entire region of Trentino-Alto Adige together with one province in Veneto, and so on.

tional Statistical Institute (ISTAT) on a representative sample of Italian households collects information on ownership of a digital decoder.[4] Panel B plots the share of households with children in a schooling age that owned a decoder in the years before and after the switchoff, separately by calendar year of the transition. The pattern is remarkably similar across areas with the exception of Sardinia, which was the first region to switch in 2008. Being an island, households traditionally faced reception problems for analog TV channels so many had already obtained a DTV even before the switchoff. Apart from Sardinia, in all other areas switching during the following year same DTV access is on an upward slow trend reaching roughly 30% of ownership by 2009 and then exhibit sharp increases in the year of the switchoff. This is shown more clearly in Panel C, which re-centers each series around the switchoff date and adds the average across all areas. Access to DTV roughly doubles – from 40% to 80% – between the year before and the year after the transition.

Changes in television content and consumption. The transition to DTV expanded the television offer at the national level by over a hundred additional digital channels, on top of the seven national channels already available under analog broadcasting. Most of these new channels were devoted to specific types of content, such as entertainment, educational programming, reality, and movies, and targeted particular audiences. Children were a major target: about a dozen new channels broadcast exclusively cartoons and other children's entertainment programs.

Using hand-collected data on programming schedules published by the Italian newspaper Corriere della Sera, we show, in Panel A of Figure 2, that the total number of hours of cartoons and other children's entertainment programs broadcast across all channels in an average day increased from 12.3 in 2007, before the DTV transition, to 179.4 in 2013, after the transition. Of this total, 168 hours were aired on digital channels, while only 11 were aired on national channels that had already been available under analog broadcasting. The

[4] The Aspects of Daily Life time-use survey constitutes a comprehensive annual investigation conducted among the resident population within private households. Utilizing a sample of 20,000 households and 50,000 individuals, the survey yields representative population estimates concerning fundamental aspects of daily existence and social conduct. Additionally, it serves as a critical data source for evaluating the integration and utilization of Information and Communications Technologies. https://www.istat.it/en/microdata/aspects-of-daily-life-2/

transition therefore implied a dramatic expansion in the supply of children's entertainment programming driven by new digital channels, with no offsetting reduction on traditional channels.

DTV also introduced one channel devoted to educational content for children (*Rai Scuola*), so in principle the transition expanded access not only to entertainment but also to educational programming. In practice, however, educational television never gained traction. We document this using data from Auditel, a private company that tracks television viewing behavior through a panel of about 16,000 households (roughly 40,000 individuals) representative of the Italian population. Each household member is assigned a personal remote control, which allows precise recording of individual viewing time, avoiding the recall errors and systematic biases typical of self-reported data.[5]

Since these data are a proprietary commercial product primarily used for pricing television advertising, they are not publicly available. For the purposes of this project, however, we obtained extracts of viewing time for three channels: two main DTV entertainment channels monitored by Auditel between 2008 and 2013, namely *Rai YoYo* and *Rai Gulp*, and the educational channel *Rai Scuola*. Panel B of Figure 2 compares the dynamics of viewing time for the combined entertainment channels with that of the educational channel around the analog switchoff. Average viewing time of children's entertainment channels increased from about 5 minutes per day before the switchoff–when only a small share of households had a decoder–to nearly 30 minutes per day two years after the transition. By contrast, viewing time for educational television remained close to zero both before and after the switch off.

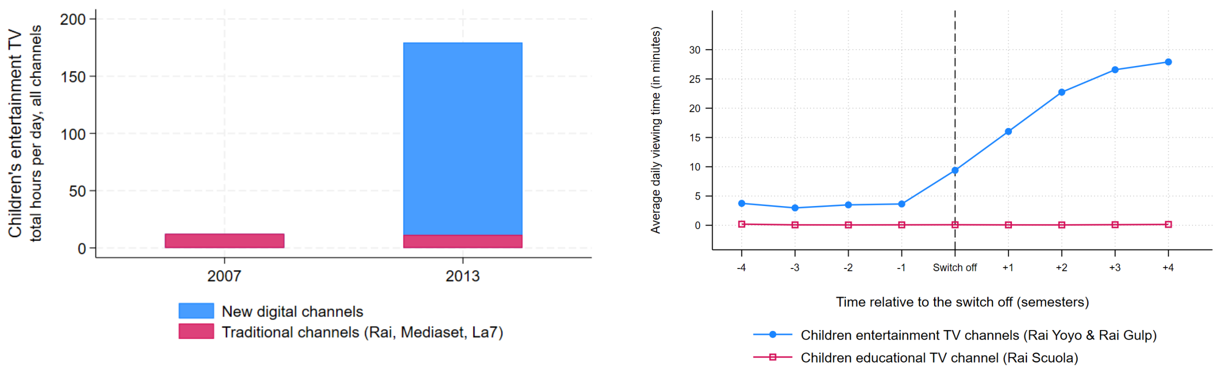
We next describe the data used to investigate the impact of this increase in the availability and actual consumption of entertainment television on students' academic performance.

[5]For example, the INVALSI questionnaires (described below) ask students to report their daily TV consumption, but these self-reported figures appear to substantially understate actual viewing. In 2013, Auditel data indicate that children aged 4–14 watched, on average, about three hours of television per day. By contrast, in the INVALSI data–covering a similar age range of primary and middle school students–average reported viewing is just above one hour per day (roughly one-third of the Auditel estimate), and only 15% of students report watching more than 1.5 hours. For this reason, we do not rely on self-reported TV viewing from the INVALSI questionnaires in our analysis. For more information on the Auditel data, see (www.auditel.it).

Figure 2: Changes in TV consumption around the transition to DTV

Panel A. Programming schedule

Panel B. Entertainment vs. educational TV



Panel A reports the total number of hours of cartoons and other children's entertainment programs broadcast across all television channels in an average day before (2007) and after (2013) the transition to digital terrestrial television (DTV). The figure distinguishes between traditional analog channels already available before the transition and new digital channels introduced with DTV. Programming information is hand-collected from television schedules published by *Corriere della Sera*. Panel B reports average daily viewing time of two children's entertainment channels (*Rai YoYo* and *Rai Gulp*) and of the educational channel (*Rai Scuola*) around the analog switch-off year ($t = 0$), using Auditel data on television viewing behavior. Viewing time is measured in minutes per day among children aged 4–14.

INVALSI standardized test scores. We measure students' educational achievement using standardized tests administered by the National Agency for the Evaluation of the Italian Education System (INVALSI). These tests have been administered annually since the spring of 2010 to the population of students in Italy enrolled in grades 2 and 5 (primary, or "elementary" school), grades 6 and 8 (lower secondary, or "middle" school), and grades 10 and 13 (upper secondary, or "high" school).[6]

Our analysis leverages information on the first four waves of INVALSI (2010-2013), for a total of 8,252,829 tests in 10,927 schools. During this period, INVALSI administered standardized tests in two core domains: numeracy (mathematics) and literacy (Italian language).[7] Test outcomes are available at the student level both as raw scores, defined as the number of correct answers, and as scores derived from a Rasch model. The Rasch transformation accounts for differences in item difficulty and yields a measure of latent ability

[6]Testing in grade 6 was discontinued starting in the 2013–2014 school year.

[7]English was introduced only much later (starting in 2018), while other subjects–such as science–were never part of the INVALSI assessment framework.

that is comparable across cohorts and test waves. Moreover, Rasch scores are standardized, allowing treatment effects to be interpreted in standard deviation units. For these reasons, our main analysis focuses on Rasch scores, though results are essentially identical when using raw standardized scores.

In addition, the INVALSI questionnaires provide information on school schedule (i.e., morning-only versus full-time schooling) and on students' socio-demographic characteristics, including gender, parental education, and citizenship. Exploring heterogeneity along these dimensions will illuminate the mechanisms behind the effect on standardized test scores. Appendix Table A1 reports the sample size and composition in terms of the student characteristics used in the heterogeneity analysis.

Identification strategy. The staggered transition to DTV across geographical areas provides a natural setting to estimate its causal effect on pupils' performance in INVALSI standardized tests within a difference-in-differences framework. We compare outcomes for pupils in provinces that transitioned to DTV earlier and later, adopting the approach of Callaway and Sant'Anna (2021) to address the well-known negative-weight problem that can arise in two-way fixed effects estimators under staggered adoption and heterogeneous treatment effects (see, e.g., De Chaisemartin and d'Haultfoeuille, 2023; Baker et al., 2025). The estimator proposed by Callaway and Sant'Anna (2021) identifies causal effects by comparing treated units at a given point in time only to units that have not yet been treated, constructing cohort–time average treatment effects that are subsequently aggregated using non-negative weights to recover overall and dynamic effects.

In our setting, provinces transitioned to DTV between 2008 and 2012, while INVALSI tests are available only from spring 2010 onward. This timing has two implications for the empirical analysis. First, it allows us to estimate up to two years of lead coefficients prior to treatment and up to two years of lag coefficients capturing the post-transition impact of DTV exposure. The lead coefficients are used to assess the plausibility of the identifying assumption that, absent the DTV transition, outcomes in provinces switching earlier and later would have followed parallel trends. Second, because the DTV rollout had already begun when the first INVALSI wave was collected, a non-negligible share of students resides in provinces that are already treated in the first observed period and therefore lack an observed pre-treatment baseline. Since the Callaway and Sant'Anna estimator requires an untreated period for each treated cohort, these early-treated areas do not contribute to the identifying variation.[8]

Turning to inference, outcomes vary at the individual (student) level, while treatment varies at the level of 16 macro-areas comprising many thousands of students (the aggregations of provinces shown in Panel A of Figure 1). In this setting, heteroskedasticity-robust standard errors are likely to be severely downward biased, as they fail to account for within-area correlation in outcomes (Moulton, 1990; Bertrand et al., 2004; Duflo et al., 2007). A standard correction is to cluster standard errors at the level of treatment variation, but with only 16 clusters, cluster-robust standard errors may themselves be unreliable and downward biased (Cameron and Miller, 2015).

To address this issue, we rely on permutation-based inference. Specifically, we compare the estimated coefficient using the true switchoff dates to the distribution of estimates obtained by randomly reassigning switchoff dates across macro-areas. Consistent with concerns regarding few-cluster bias, permutation-based inference yields substantially more conservative p-values and confidence intervals than conventional clustered standard errors. Both sets of results are reported in the Results section.

3 Results

Figure 3 plots the estimated effect of the transition to digital terrestrial television (DTV) on standardized test scores in literacy and math (left and right columns, respectively), along with 95% confidence intervals based on 200 permutations of (placebo) switchoff dates.[9] The top panels pool pupils across all schools, while the middle and bottom panels examine heterogeneity by school level and school schedule, respectively. In each graph, we also report

[8] These early-treated areas correspond to the first six macro-areas that switched off the analogue signal, largely corresponding to Sardinia, western Piedmont, Trentino-Alto Adige, Campania, Lazio, and Valle d'Aosta; see Panel A of Figure 1. Together, they account for 2,397,716 students out of 8,252,826 in the full sample (29.0%), with virtually identical shares across primary and lower-secondary schools.

[9] Confidence intervals are constructed by inverting permutation tests based on the randomization distribution of the estimator (Lehmann and Romano, 2005; Imbens and Rubin, 2015).

the estimated effect two years after the transition and the corresponding permutation-based p-value. Table 1 reports the full set of lead and lag coefficients together with conventional and permutation-based p-values (reported in parentheses and brackets, respectively) for all specifications in Figure 3 (columns 1–5). The difference between the two highlights the importance of inference procedures that account for the small number of treatment clusters. Permutation p-values are often an order of magnitude larger than conventional cluster-robust p-values, implying substantially more conservative statistical inference.

Across all specifications, estimated coefficients in the pre-treatment periods are small and statistically indistinguishable from zero, providing support for the identifying assumption that test scores in provinces transitioning earlier and later would have followed parallel trends in the absence of the digital transition.

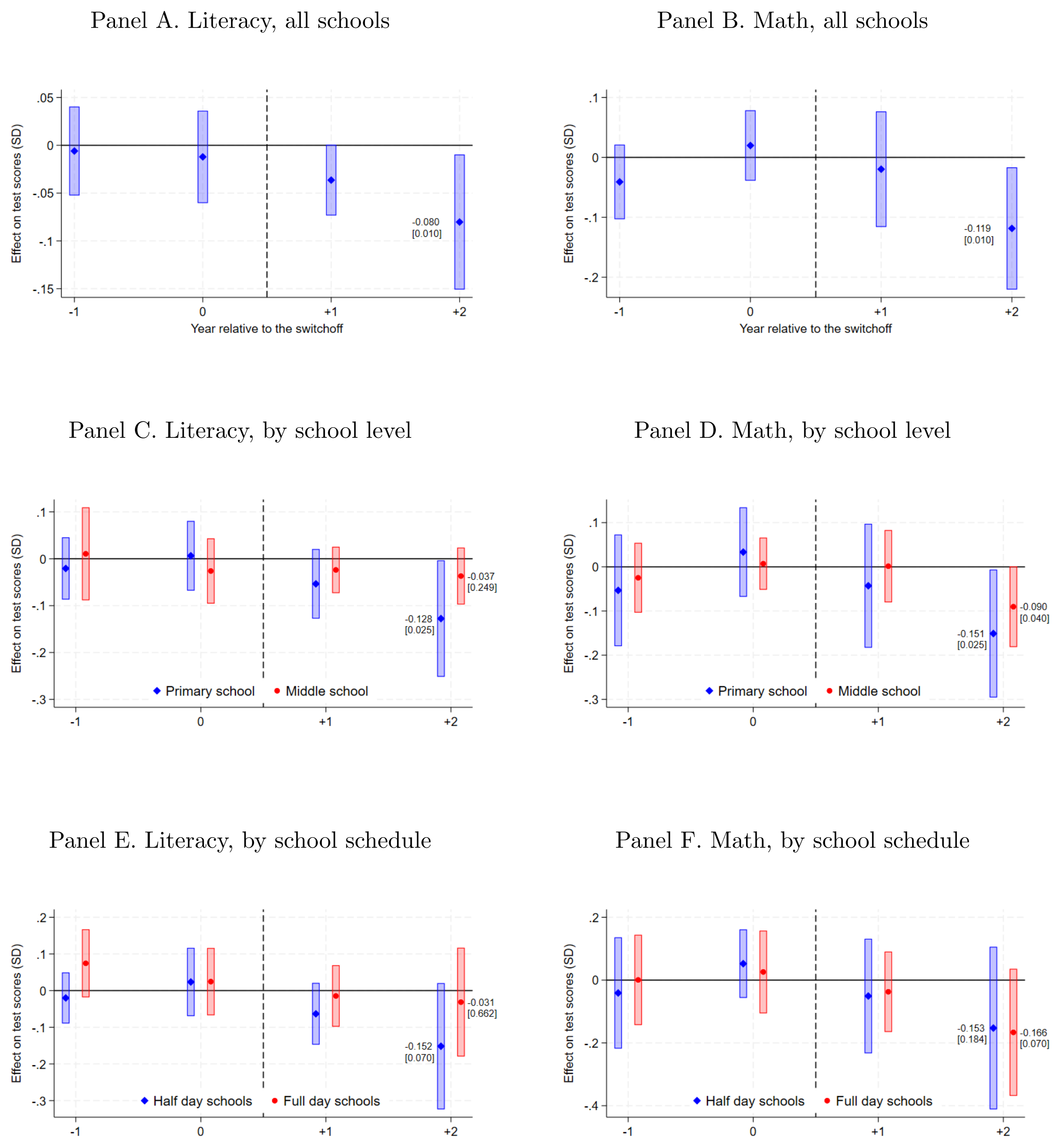
Turning to post-treatment effects, Panels A and B of Figure 3 show that the transition to DTV leads to a progressive decline in student performance. In the first calendar year after the transition ($t = +1$), test scores decrease modestly relative to not-yet-treated areas–by about 3.6% of a standard deviation in literacy and 2% in math. This limited short-run effect is consistent with the timing of exposure: at the time of testing (in the spring of each calendar year), students had been exposed to DTV for only a few months (less than six months, with a median of about five).

By contrast, effects become sizable in the second year after the transition ($t = +2$). Literacy scores decline by approximately 8% of a standard deviation, while math scores decline by about 12%. Both estimates lie in the tails of the empirical distribution of placebo effects and are associated with permutation-based p-values of approximately 0.01; see Appendix Figure A1. Moreover, the estimates are not driven by any single transition area: they remain virtually identical when sequentially dropping each of the macro-areas contributing to the identifying variation in the staggered difference-in-differences estimator (see Appendix Figure A2).[10]

Scaling these reduced-form estimates by the increase in access to digital channels around the switchoff (roughly 40%, see Section 2) implies effects of about -0.20 standard deviations

[10] As discussed in Section 2, the first six macro-areas switched to DTV before the first INVALSI wave in 2010 and therefore do not contribute to the identifying variation in the staggered difference-in-differences estimates. For this reason, the leave-one-out exercise only considers macro-areas 7–16.

Figure 3: The effect of DTV, main results



Notes: The figure reports event-study estimates of the effect of the transition to digital terrestrial television (DTV) on standardized test scores in literacy (left column) and mathematics (right column). Coefficients are obtained from a difference-in-differences specification following Callaway and Sant'Anna (2021), comparing provinces that have transitioned to DTV with those not yet treated. The horizontal axis measures time relative to the switch-off year ($t = 0$). Outcomes are standardized test scores expressed in standard deviation units. Vertical bars represent 95% confidence intervals constructed via permutation-based inference using 200 random assignments of transition timing across macro-areas. Panels A–B report estimates pooling all schools, Panels C–D split the sample by school level (primary vs. middle), and Panels E–F by school schedule (half-day vs. full-day).

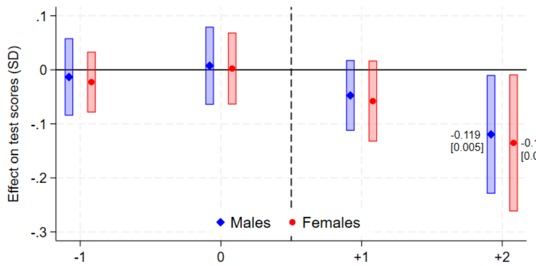
Table 1: The effect of DTV, main results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All	School level		School schedule		Migrant background	
	Sample	Primary	Middle	Half-day	Full-day	Natives	Migrants
Literacy							
$t = -1$	-0.006	-0.021	0.011	-0.020	0.075	-0.013	-0.113
	(0.716)	(0.077)	(0.692)	(0.142)	(0.001)	(0.353)	(0.149)
	[0.806]	[0.428]	[0.806]	[0.622]	[0.075]	[0.587]	[0.045]
$t = 0$ (DTV transition)	-0.012	0.006	-0.026	0.024	0.025	0.010	0.006
	(0.573)	(0.819)	(0.285)	(0.527)	(0.055)	(0.748)	(0.894)
	[0.602]	[0.831]	[0.338]	[0.572]	[0.562]	[0.781]	[0.886]
$t = +1$	-0.036	-0.053	-0.024	-0.063	-0.015	-0.064	0.000
	(0.010)	(0.000)	(0.421)	(0.000)	(0.440)	(0.000)	(0.999)
	[0.030]	[0.134]	[0.318]	[0.124]	[0.647]	[0.055]	[0.995]
$t = +2$	-0.080	-0.128	-0.037	-0.152	-0.031	-0.140	-0.065
	(0.000)	(0.000)	(0.060)	(0.000)	(0.013)	(0.000)	(0.266)
	[0.010]	[0.025]	[0.249]	[0.070]	[0.662]	[0.030]	[0.239]
Diff. by group ($t = +2$)		0.091		0.120		0.075	
		[0.114]		[0.149]		[0.303]	
Mathematics							
$t = -1$	-0.041	-0.053	-0.025	-0.041	0.001	-0.046	-0.154
	(0.227)	(0.261)	(0.434)	(0.494)	(0.992)	(0.312)	(0.054)
	[0.159]	[0.308]	[0.542]	[0.697]	[1.000]	[0.393]	[0.050]
$t = 0$ (DTV transition)	0.020	0.033	0.007	0.052	0.026	0.042	-0.017
	(0.269)	(0.203)	(0.739)	(0.132)	(0.581)	(0.101)	(0.697)
	[0.458]	[0.468]	[0.771]	[0.294]	[0.627]	[0.338]	[0.632]
$t = +1$	-0.020	-0.043	0.001	-0.051	-0.037	-0.041	-0.042
	(0.422)	(0.037)	(0.960)	(0.015)	(0.259)	(0.056)	(0.087)
	[0.637]	[0.438]	[0.965]	[0.428]	[0.433]	[0.527]	[0.343]
$t = +2$	-0.119	-0.151	-0.090	-0.153	-0.166	-0.142	-0.180
	(0.000)	(0.000)	(0.001)	(0.000)	(0.018)	(0.000)	(0.011)
	[0.010]	[0.025]	[0.040]	[0.184]	[0.070]	[0.050]	[0.045]
Diff. by group ($t = +2$)		0.061		0.014		0.038	
		[0.264]		[0.886]		[0.398]	
N. students	3,292,811	1,643,270	1,649,541	1,174,785	647,352	1,587,006	348,222
N. schools	10,927	8,929	7,159	8,229	5,642	8,929	8,589

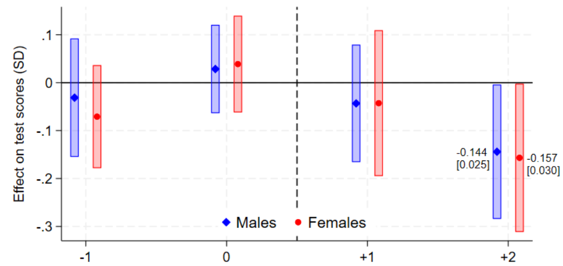
Notes: The table reports event-study estimates of the effect of the transition to digital terrestrial television (DTV) on standardized test scores in literacy and mathematics. Coefficients are obtained from a difference-in-differences specification following Callaway and Sant'Anna (2021), comparing provinces that have transitioned to DTV with those not yet treated. Outcomes are standardized test scores expressed in standard deviation units. Rows indexed by −1, 0, +1, and +2 denote years relative to the switch-off date. P-values based on conventional cluster-robust standard errors (clustered at the macro-area level) are reported in parentheses; p-values based on permutation inference using 200 random assignments of transition timing across macro-areas are reported in brackets. Columns 1–5 correspond to the specifications reported in Figure 3, while Columns 6–7 report additional heterogeneity by migration background. "Diff. by group" reports the difference between the estimated coefficients at $t = +2$ across the two groups considered in each heterogeneity specification, together with the corresponding permutation-based p-value.

Figure 4: The effect of DTV, heterogeneity by individual characteristics

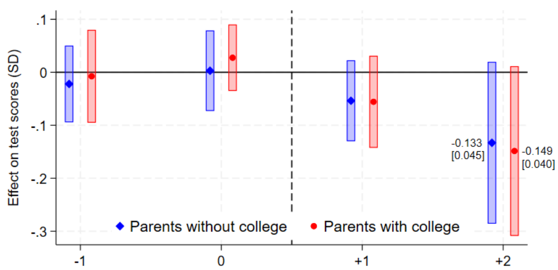
Panel A. Literacy, by gender



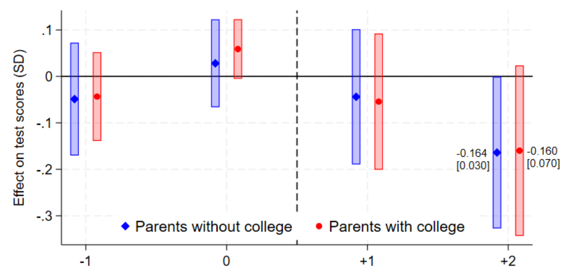
Panel B. Math, by gender



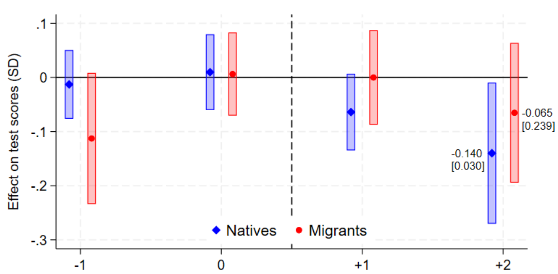
Panel C. Literacy, by parental education



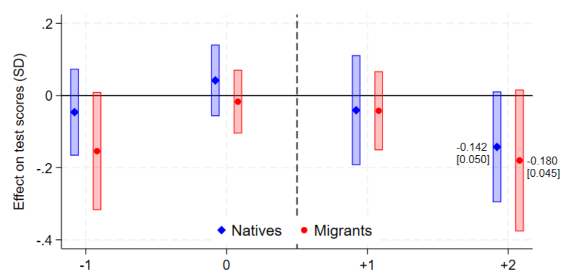
Panel D. Math, by parental education



Panel E. Literacy, by migration background



Panel F. Math, by migration background



Notes: The figure reports event-study estimates of the effect of the transition to digital terrestrial television (DTV) on standardized test scores in literacy (left column) and mathematics (right column), separately by individual characteristics. Coefficients are obtained from a difference-in-differences specification following Callaway and Sant'Anna (2021), comparing provinces that have transitioned to DTV with those not yet treated. The horizontal axis measures time relative to the switch-off year ($t = 0$). Outcomes are standardized test scores expressed in standard deviation units. Vertical bars represent 95% confidence intervals constructed via permutation-based inference using 200 random assignments of transition timing across macro-areas. Panels A–B split the sample by gender, Panels C–D by parental education (parents with vs. without college education), and Panels E–F by migration background (native vs. immigrant pupils). The analysis is restricted to primary school students.

in literacy and -0.30 in math for actual exposure.

These average effects conceal substantial heterogeneity by school level. Panels C and D of Figure 3 show that the negative impact is concentrated among primary school pupils. At $t = +2$, literacy and math scores decline by approximately 13% and 15% of a standard deviation, respectively. By contrast, effects for middle school students are much smaller in literacy (around -3.7%, p-value 0.18) and remain moderate in math (around -9%, p-value 0.035). While from a purely statistical perspective we cannot reject equality of effects across school levels (see p-values reported in Table 1), this likely reflects the conservativeness of our permutation-based inference. In any case, the magnitude of the differences is sizable and points to a substantially stronger impact among younger students.

The greater effect on primary school pupils can be interpreted through two complementary mechanisms. First, and more generally, it aligns with extensive evidence that early-life shocks have larger effects on skill formation (Cunha and Heckman, 2007; Heckman, 2007; Cunha et al., 2010; Almond and Currie, 2011). A key mechanism emphasized in this literature is that self-regulation and executive control–critical buffers against distraction–are still developing in childhood; see also evidence from psychology and cognitive sciences (Diamond, 2002, 2013; Best and Miller, 2010; Blair and Raver, 2012, 2015; Shonkoff et al., 2012).

Second, and more specifically to the present context, pupils in middle school may already have greater access to alternative digital media such as internet-enabled computers and, increasingly during the period we study, early smartphone adoption (Rideout and Robb, 2019), so that the marginal expansion of television content represents a weaker shock to their overall media environment, and more generally to their daily habits.

A related mechanism is time substitution, whereby additional screen time displaces learning activities (Gentzkow and Shapiro, 2008; Kearney and Levine, 2019). To investigate the relevance of this mechanism, Panels E and F of Figure 3 compare the effect on primary school students attending only in the morning –which account for nearly two thirds of the sample, see Appendix Table A1– with that on students attending also in the afternoon.[11]

If time displacement is an important channel, the transition to DTV should matter

[11] We focus this analysis, and the remaining ones in Figure 4, on primary schools in light of the results in Panels C and D of Figure 3. Appendix Figure A3 shows that results are very similar when pooling together primary and middle schools.

more for students attending only in the morning, who have more discretionary time in the afternoon. The results for literacy are consistent with this prediction: the effect is entirely driven by morning-only schools (15.2%, p-value 0.07), while it is close to zero in full-time schools. By contrast, the effects on math are essentially identical across the two groups.

Figure 4 explores heterogeneity along additional dimensions. Panels A and B show that the estimated effects are virtually identical for male and female pupils. This finding is notable in light of evidence that other forms of media exposure-such as social media or video games–have gender-differentiated impacts on youth outcomes (e.g., Braghieri et al., 2022; Twenge et al., 2019). By contrast, television appears to affect academic performance similarly across genders, consistent with mechanisms such as time displacement and reduced attention that are not strongly gender-specific.

Panels C and D show no meaningful differences by parental education, suggesting that children from higher socio-economic status backgrounds are not better insulated from the effects of increased television exposure. Panels E and F show that pupils with a migration background experience smaller (and statistically insignificant) effects in literacy compared to natives (approximately -6.5% vs. -14%, p-value 0.21).[12] One explanation is that television may facilitate language acquisition, partially offsetting negative effects for immigrant students along this dimension, while still being detrimental along other dimensions. Consistently with this explanation, effects on math are similar between immigrants and natives.

Overall, the patterns in Figures 3 and 4 are consistent with three complementary mechanisms: (i) increased exposure to entertainment content crowding out educational activities (time substitution); (ii) reduced attention and self-regulation among younger children; and (iii) a smaller marginal impact for older students who already had access to alternative media. In addition, for children with a migration background, exposure to television may partly facilitate language acquisition, potentially offsetting negative effects on literacy, though only partially and with no corresponding benefit in math.

[12] Full estimation results for the specification in Panels E and F of Figure 4 are reported in Table 1 (columns 6-7). For space reasons, we do not report the results for Panels A-D, as there is no meaningful heterogeneity across groups.

4 Conclusions

The rapid expansion of digital media has dramatically increased children's exposure to entertainment content, raising concerns about its consequences for learning and cognitive development. This paper provides causal evidence on this issue by exploiting the transition from analog to digital television in Italy, which sharply expanded the availability of children's entertainment programming. We find that access to digital television significantly reduced standardized test scores, with particularly large effects among younger children and among students with more discretionary time outside school.

The transition we study predates the rise of streaming platforms and social media, and therefore provides a useful benchmark for understanding the educational consequences of the much broader expansion in entertainment content brought about by platforms such as Netflix, YouTube, and TikTok. In this perspective, our findings raise concerns that increasingly immersive and personalized media environments may have sizable unintended consequences for children's human capital formation.

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A Online Appendix

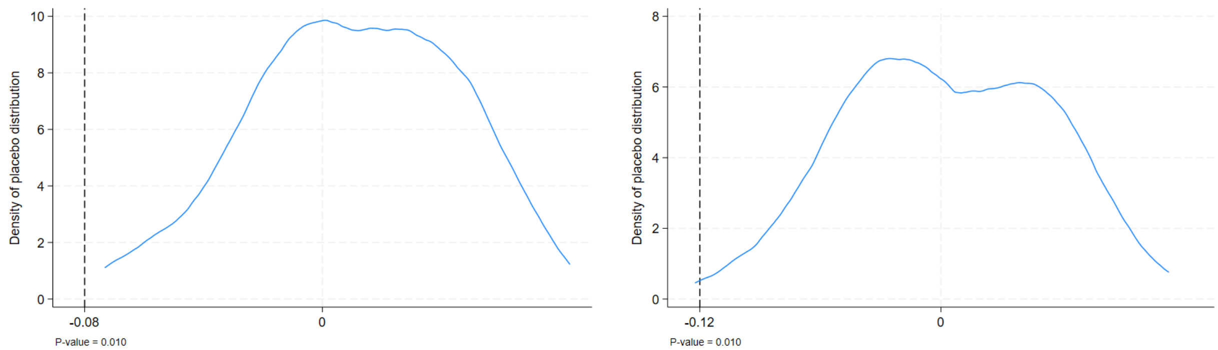
Table A1: Sample size and composition

	Total sample (2nd, 5th, 6th, 8th grade)	**Primary** (2nd, 5th grade)	**Secondary** (6th, 8th grade)
Schools	10,927	8,929	7,159
Students taking INVALSI tests	8,252,826	4,118,668	4,134,158
School years:			
2009–2010	2,053,163	1,029,283	1,023,880
2010–2011	2,105,798	1,042,219	1,063,579
2011–2012	2,068,985	1,027,679	1,041,306
2012–2013	2,024,880	1,019,487	1,005,393
Student characteristics:			
attending full-day	30.3%	34.1%	22.9%
female	49.5%	49.5%	49.4%
parents with college	16.4%	17.2%	14.8%
immigrant background	10.0%	10.1%	10.0%

Figure A1: Permutation test comparing the estimated effect of DTV transition at the true switchoff date vs. 200 permutations of placebo dates

Panel A. Literacy

Panel B. Math

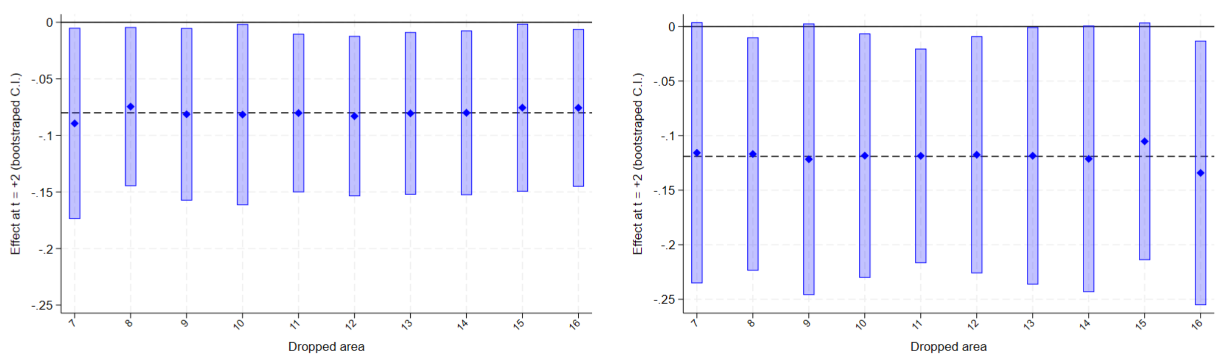


Notes: The figure compares the estimated effect of the transition to digital terrestrial television (DTV) on standardized test scores at the true switch-off dates with the empirical distribution of placebo estimates obtained by randomly reassigning transition timing across macro-areas. Panels A and B report results for literacy and mathematics, respectively. The vertical dashed line indicates the estimated coefficient at $t = +2$ using the true transition dates, while the solid curve reports the kernel density of the corresponding placebo distribution based on 200 random assignments. P-values are computed as the share of placebo estimates with absolute value greater than or equal to the estimated coefficient under the true assignment.

Figure A2: Leave-one-out estimates of the effect of DTV at $t = +2$

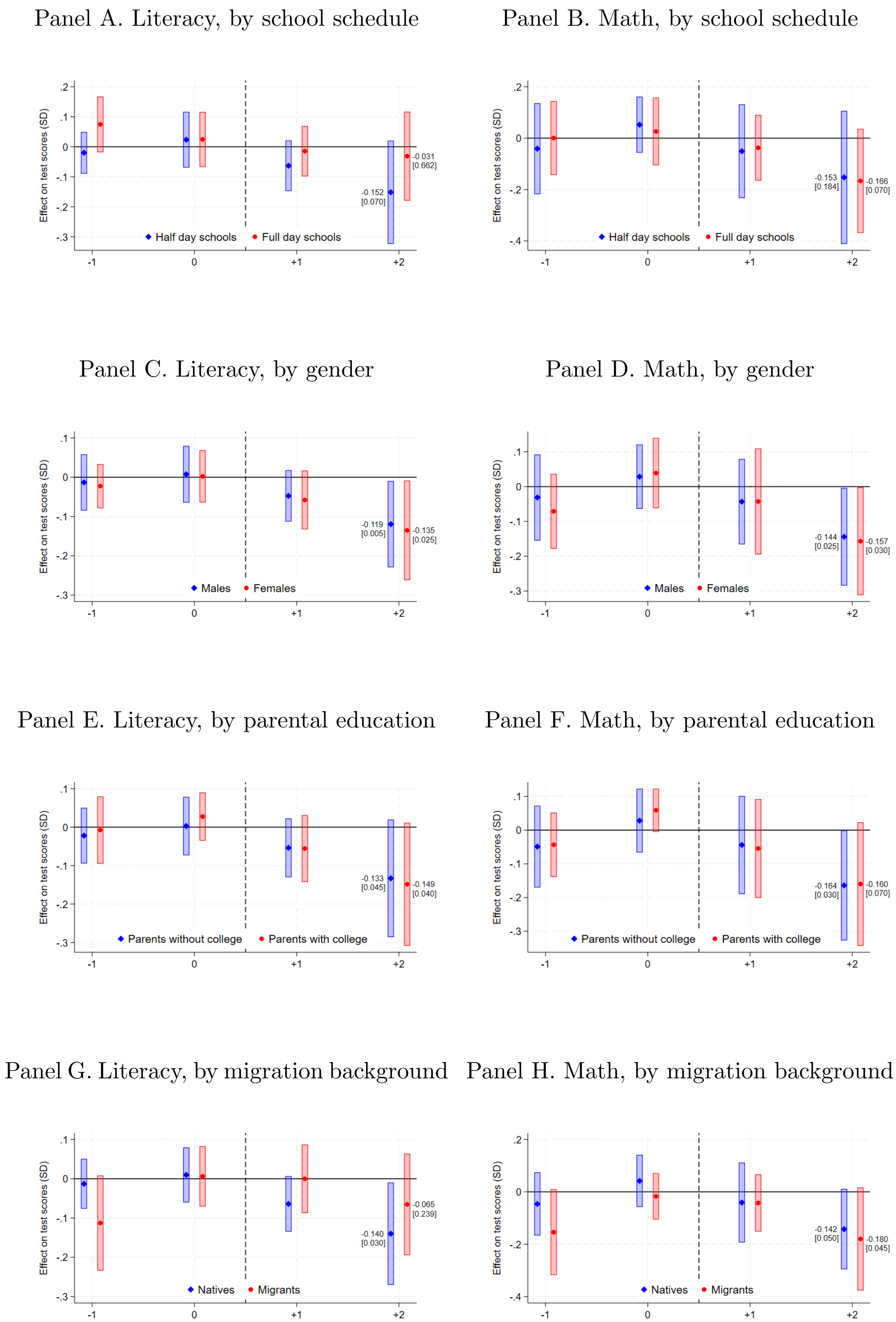
Panel A. Literacy

Panel B. Math



Notes: The figure reports leave-one-out estimates of the effect of the transition to digital terrestrial television (DTV) on standardized test scores in literacy (Panel A) and mathematics (Panel B) two years after the switch-off ($t = +2$). Each estimate is obtained by re-estimating the baseline specification after excluding one macro-area at a time from the sample. The horizontal axis identifies the excluded macro-area. Vertical bars represent 95% confidence intervals constructed via permutation-based inference using 200 random assignments of transition timing across macro-areas. Only macro-areas contributing to the identifying variation are considered; the first six macro-areas that switched to DTV before the first INVALSI wave in 2010 are omitted because they do not contribute to identification in the Callaway and Sant'Anna (2021) estimator.

Figure A3: The effect of DTV, additional heterogeneity analysis when pooling together primary and middle school



Notes: The figure reports event-study estimates of the effect of the transition to digital terrestrial television (DTV) on standardized test scores in literacy (left column) and mathematics (right column), separately by student characteristics when pooling together primary and middle school students. Coefficients are obtained from a difference-in-differences specification following Callaway and Sant'Anna (2021), comparing provinces that have transitioned to DTV with those not yet treated. The horizontal axis measures time relative to the switch-off year ($t = 0$). Outcomes are standardized test scores expressed in standard deviation units. Vertical bars represent 95% confidence intervals constructed via permutation-based inference using 200 random assignments of transition timing across macro-areas. Panels A–B split the sample by school