Distraction or Teaching Tool: Do Smartphone Bans in Schools Help Students?

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Abstract

How smartphone usage affects learning and well-being among children and teenagers is a concern for schools, parents, and policymakers. However, causal evidence of the effect that new technology such as smartphones has on student outcomes remains scarce. This paper studies the effect of banning smartphones from the classroom on students' educational outcomes and incidents of bullying in Norwegian middle schools. Combining detailed administrative data with survey data on middle schools' smartphone policies, I show, through an event-study design that banning smartphones significantly increases girls' test scores in mathematics, increases their likelihood of attending an academic high school track, and decreases incidents of bullying. Hence, banning smartphones from school could potentially be a low-cost policy tool to improve educational outcomes and reduce bullying.

JEL classification: I21, I31, J24, O33

Keyword: Smartphones, technology, grade point average, bullying, education

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1 Introduction

The increasing use of technology, particularly the growing smartphone usage, by children and adolescents has led to concerns about the effects on young people's cognitive, physical, and socioemotional development. In the United States, more than 95% of teenagers report owning a smartphone or having access to one (Pew Research Center 2018) and, on average, teenagers spend more than 4 hours online per day, not including time spent using screens for school or homework (OECD 2019*a*). Of particular concern is whether screen-based activities are detrimental to children and adolescents' learning and well-being. Currently, there is a policy debate on whether smartphones and tablets should be used as teaching tools in classrooms or whether they distract students. For instance, in France, the government recently banned mobile phones during school hours for students from kindergarten to high schools, arguing that they distract students from learning (Rubin & Peltier 2018). By contrast, the New York mayor's office removed a 10-year ban on mobile phones in public schools in 2015, stating that the ban increased inequalities among students (Allen 2015).[1]

While technology has generally been viewed as increasing productivity (Acemoglu & Dell 2010, Brynjolfsson & Yang 1996), the impact of smartphone use in schools on student outcomes and well-being is ambiguous (Amez & Baert 2020, OECD 2019*b*). Although students might use them in a productive way, smartphones can act as a distraction. Thus, a smartphone ban could potentially either help or hinder student learning. Both the behavioral and psychology literature have found multitasking to be detrimental not only to attention, but also more specifically to learning (see, e.g., Smith et al. 2011, Abouk & Adams 2013, Rana et al. 2019, Mendoza et al. 2018, Glass & Kang 2019). Additionally, if phones lower the cost of bullying by making it less salient for teachers and adults, a ban could lower the incidence of bullying and thereby indirectly enhance human capital accumulation. Despite these contrasting theories, there is little causal evidence on the effect that a smartphone ban would have on students' academic outcomes and, particularly, on bullying.

This paper contributes to this debate by studying the effects of banning smartphones from Norwegian middle schools on students' educational outcomes and the incidence of bullying. I leverage quasi-experimental variations in Norwegian middle schools introducing smartphone bans that limited usage among students. I employ a nonparametric event-study design to iden-

[1] It was argued that the ban increased financial inequalities and inequity as certain schools, especially those in low socioeconomic areas, had metal detectors at the school entrance and students were required to pay outside vendors to store phones during school hours. In addition, it was argued that lifting the ban assisted parents to stay in contact with their children, especially before and after school.

tify causally the time-varying impact of banning smartphones from the classroom on students' outcomes and bullying. The focus is on three main outcomes: (i) grade point average (GPA) at the end of middle school, (ii) the probability of attending an academic rather than a vocational high school track, and (iii) incidents of bullying. Specifically, I evaluate whether a smartphone ban affects students' GPA at the end of middle school and their progression into an academic or vocational high school track. In addition, I combine school-level aggregated data on students' perceptions of bullying to evaluate the effect that a smartphone ban has on bullying. All three outcomes are important indicators for later education and success in the labor market. Moreover, I test for important differences in the effect of smartphone bans across sub-groups.

There are no national guidelines on smartphone use in Norwegian schools. Instead, schools make autonomous decision on whether to allow or ban smartphones. Over the last 10 years, this has resulted in variations in the timing of smartphone bans being implemented across schools. As there is no centrally collected information on smartphone bans in schools, I used a survey to collect data from Norwegian middle schools on their smartphone policies, and whether and when they had introduced any smartphone regulations. Then, I matched schools' responses from the survey to Norwegian Registry data, which include information on middle-school GPAs – which are calculated as a weighted average of teachers' assessments combined with externally graded exams and test scores – and individuals' choices of academic or vocational high schools. A bullying measurement is available from the Norwegian Pupil Survey, implemented yearly since 2007 by the Norwegian Directory for Education and Training.

The validity of my research design rests on the assumption that the timing of a school adopting a smartphone ban is uncorrelated with other determinants of student outcomes. I provide different pieces of evidence that the main identification assumption is likely to hold. First, I show that school, student, and teacher baseline characteristics cannot predict the timing of when a school implements a ban. Second, I show that schools that implemented smartphone bans in different years did not experience changes in baseline characteristics prior to the introduction of the bans. Moreover, the event-study framework demonstrates that both pre- and post-policy, school, teacher, and student characteristics do not change. This suggests that endogenous compositional changes are not driving my results.

The findings show that post-ban, girls who are exposed to a smartphone ban from the start of middle school make gains in externally graded mathematics exams and have, on average, 0.25 standard deviations higher mathematics test scores than girls not exposed to a ban. Additionally, I find that girls are 6-7 percentage points more likely to attend an academic high school track after experiencing a ban. This effect amounts to a 12–14% point increase in the probability of attending an academic high school track relative to the pre-ban years. This effect is significant for girls who are exposed to a smartphone ban for at least 2 years or more in middle school.

The findings also show that post-ban, girls have significantly higher middle-school GPA when they attend a middle school that bans students from bringing their phones to schools or alternatively, schools where students have to hand their phones in before the lecture starts. Girls who are exposed to a smartphone ban from the start of their 3-year middle-school education at these schools, gain on average 0.10 of a standard deviation in GPA compared with girls without exposure to the ban. For girls who are partially exposed to a smartphone ban during their middle-school years, or girls that allow their students to use their phones during breaks and only requires phones to be on silent mode during lectures there is no effect. The magnitude of GPA and the probability of attending an academic high school track is larger among girls from low socioeconomic backgrounds. For instance low socio-economic girls, who are exposed from the start of their middle school education, have on average 0.09–0.11 standard deviations higher GPA and are 5–6 percentage points more likely to attend an academic high school track compared to unexposed girls. These important differences suggest that unstructured technology is especially distracting for students from low socioeconomic families, whereas students from high socioeconomic families do not experience any negative externalities. I find no effect on boys' GPA or on the probability of them attending an academic high school track. The heterogeneity in the patterns between girls and boys could result from the substantially higher phone usage among girls. More than 70% of girls of middle-school age in Norway report that they spend more than 2 hours a day on their phones, whereas only 54% of boys say the same. Additionally, almost 60% of girls report that they spend 2 or more hours on social media, whereas comparison only 32% of boys do the same(Medietilsynet 2018).

In addition, my results show that banning smartphones overall lowers the incidence of bullying between 0.29–0.40 of a standard deviation among girls when girls are exposed from the start of their middle school years. For boys, I show that there are important differences post-ban in bullying depending in the exact ban that a school implements, and by the socio-economic status of the schools. Boys attending a lower socio-economic school or a school that bans phones throughout the day experience a decline 2 years after a ban implementation in bullying relative to pre-ban years by -0.35 and -0.83 standard deviations, respectively. In addition, the decline in bullying among both girls and boys are driven by pupils who attend smaller schools. Hence, by banning smartphones, schools not only positively impacted educational outcomes, but also decreased the level of bullying.

I contribute to the literature in several important ways. Although two existing studies examine the effect of banning mobile phones from the classroom on test scores (Beland & Murphy 2016, Kessel et al. 2020), my study, to the best of my knowledge, is the first to examine the causal effect of banning smartphones on students' progression into high school education. More generally, a handful of studies investigate phone use and its association with students' higher education outcomes (see, e.g., Amez & Baert 2020) but the majority of these are descriptive, with the exceptions of Beland & Murphy (2016) and Kessel et al. (2020). Similar to this paper, these two studies investigate how mobile phone bans affect students' test scores in the UK and Sweden, respectively. Beland & Murphy (2016) document that banning mobile phones has a positive effect on test scores, especially for disadvantaged and underachieving pupils. As Beland & Murphy (2016) study student outcomes between 2001–2011, their results largely cover a period when mobile phone ownership was much lower, smartphones barely existed, and phones had little value as a teaching tool. Today, this situation is very different. Additionally, my study provides novel evidence not only on test scores, but also on how banning smartphones affects several dimensions of student outcomes.

Kessel et al. (2020) study the effect of banning mobile phones on test scores in a much more recent time period, 1997–2018. They find no effect of banning mobile phones on students' test scores. However, their data are aggregated at the school level, restricting them from examining heterogeneous effects across different individuals. The data I use allow for an in-depth heterogeneity analysis throughout the student's schooling. For this reason, I can shed light on the consequences of unstructured technology in the classroom and the impact it has on the gender and socioeconomic gap in education (Almås et al. 2016, Autor & Wasserman 2013). In addition, the results from this study are of direct policy relevance as schools and policy makers constantly seek innovative ways of improving student outcomes.

The most novel contribution of this paper lies in providing the first causal evidence that banning smartphones lowers the incidence of bullying. A few previous papers have found a negative relationship between social well-being and later lifetime outcomes, including education and earnings (Currie & Stabile 2006, Lundborg et al. 2014). More specifically, bullying has been found to have severe physical and emotional long-term consequences for students. The large individual and societal cost has increasingly led teachers, parents, policymakers, and the media to draw attention to bullying and methods to stop it. Despite this, there has been a lack of credible causal evidence how to tackle bullying. My results suggest that a low-cost intervention such as banning smartphones from schools might be an effective policy tool to reduce bullying. The potential costs of failing to treat bullying in schools are large, as being bullied as a child or teenager influences adult health, education, and earnings (Drydakis 2014). The long-term societal cost of bullying is estimated at 1.7 million USD per bullied person (Nilson Lundmar et al. 2016).

More generally, this study contributes to the literature on technology in the classroom and the impact on student's achievements. Most previous studies focus on the impact of introducing or having access to technology, such as introducing computers in the classroom and the impact on student achievement. However, the resulting evidence is mixed (Hall et al. 2019, Escueta et al. 2017, Barrow et al. 2009, Banerjee et al. 2007, Angrist & Lavy 2002). Unlike these studies, I consider a type of technology that is highly accessible to teenagers but, in contrast with the computers in the classroom, is not necessarily considered a teaching tool.

The remainder of the paper is structured as follows. Section 2 describes the institutional setting. Section 3 describes the data and section 4 describes the identification strategy. Section 5 presents the empirical findings and section 6 discusses several robustness checks of the results. Section 7 discusses the results and section 8 concludes.

2 Institutional Background

Norwegian compulsory education starts at 6 years of age and lasts for 10 years. There are two levels of compulsory education: primary school (grades 1–7) and middle school (grades 8–10). Usually, students commence middle school in the year in which they turn 13 and finish compulsory schooling in the year that they turn 16 years old.

Compulsory education is financed by grants from the central government as well as local income taxes. The syllabuses are centrally determined by the Norwegian Directorate for Education and Training. There is no streaming by ability in compulsory education. In primary school, children are not graded. In middle school, grades are set according to national standardized learning goals and students take standardized national tests in grades 5, 8, and 9. In most counties, the scores from the exit exams in middle school and grades from teachers are crucial for admission into different high schools.[2]

Most students attend public schools. In 2019, only 4% of children attended a private or independent school. Municipalities are responsible for organizing compulsorily schooling in public schools. To receive public funding, schools are not allowed to charge any tuition fee. School assignment in public primary school is based on fixed school catchment areas within municipalities through a distance-from-home-rule.

Despite the clear rules on educational content, the Norwegian Directorate for Education and Training gives school principals the discretion to determine how to allocate funds, what

[2] Assignment to high schools varies across counties. Twelve of the 19 counties in Norway had a free school choice system in 2016. In rural counties, geographic criteria still largely determine student high school choice.

teachers to hire, and what detailed rules are imposed within school grounds. By law, each school has to have a stated code of conduct following the Norwegian Education Act, §9 A-10. However, it is up to each school to decide what kind of rules and regulations to include, as long as they are within the framework of the Education Act, the Human Rights Act, and private school laws. Each school's code of conduct should state the rights and obligations of the students and include rules about conduct and the measures that can be used against students who violate the rules. Each municipality is responsible for ensuring that each school has elaborated its code of conduct.

Smartphone bans are one rule that each school can determine. As there are no national guidelines or recommendations over students' phone usage in school, schools are free to decide their own policy. That is, schools are free to regulate students' phone usage within the framework of the school regulations by, for example, prohibiting the use of smartphones during lectures. However, schools cannot forbid students from bringing their smartphone to school, as schools cannot regulate the leisure time of the students, i.e., their use on their way to and from school. If students do not comply with the rules, the schools may take measures against the students. In regard, to smartphone usage, for instance, a teacher may seize a student's phone during school hours if they use it in a manner against the school rules. However, schools are not allowed to keep students' phones after the school day ends (Utdanningsdirektoratet 2020*b*).

After middle school, students may enroll in high school (grades 11–13). High schools are organized at the county level. All student aged 16 to 23 years in Norway have a statutory right to enrollment at high school. This right is at the county level and does not ensure enrollment in a specific school or program. About 98% of students enroll in high school in Norway in the first year. About 50% of the students enroll in general studies, 45% in vocational programs, and 3% in alternative training plans.[3]

3 Data

For this study, I link three primary data sources: a compilation of Norwegian administrative data sets, including the national educational registers, family registers, and tax registries; a nationwide pupil survey; and data on middle schools' smartphone policies. I study a sample of students who completed grade 10 between 2010 and 2018. The combined data sources allow me to explore how smartphone policy affects students' educational outcomes and bullying, using a dynamic event-study design together with a host of robustness checks.

[3]Note that only 80% of students initially enrolled in general studies programs graduate and that graduation rates for vocational programs are even lower.

3.1 Individual-level data

The Norwegian Registry data cover the entire population in Norway up to 2018 and are a collection of different administrative registers, including the central population registry, the family register, the education register, and the earnings and tax register. From these registers, I obtain detailed background information about children and their parents on demographic variables, including gender, date and place of birth, residency, educational attainment, earnings, and immigration status. The parental identifier enables me to match children to their parents. Earnings are not top-coded and include all pension-qualifying income, that is, labor earnings, taxable sickness and unemployment benefits, and parental leave payments.

Schools report student grades directly to Statistics of Norway, and grades are available for cohorts born between 1986 and 2002. This includes grades set by the teacher and those from externally graded exams. From grade 8, students begin to receive teacher-awarded grades in each subject. In the final year of middle school, students take written and oral exams. Three days before the exams, students are informed which subjects their exams will cover. Their written exam could be in mathematics, Norwegian, or English, and with exam subject being decided at the school level. Oral exams are quasi-randomly selected at the student level and, in addition to mathematics, English and Norwegian, could cover a second language, social science, religion, or natural science. Both written and oral exams are externally graded, with the grades ranging from 1 (the lowest grade) to 6 (the highest grade).

At the end of grade 10, all students obtain a diploma with a total GPA that represents the weighted total of all teacher-awarded grades combined with the exam grades. The middle-school GPA ranges from 0 to 60, where 60 is the best possible grade. These grades are used when applying for high schools and high school programs in a majority of counties. As such, these are high-stakes tests because the scores have long-run impacts on educational possibilities.

Additionally, the education registry contains national exam test scores for cohorts born between 1997–2002. National exams are nationally organized and externally graded. Students take national exams in mathematics, reading, and English in grades 5 and 8. In grade 9, students take a national exam in mathematics and reading. Information from the national exams forms the basis for undergraduate assessment and quality development at all levels of the school system. I use the test scores from grade 5 to condition on students' achievements before they enter middle school.[4] High school programs are generally divided between academic and vocational tracks. The data allows me to identify in what type of high school program students enroll in the first year.

[4]In contrast to the test in grade 10, these national exams involve smaller stakes for students

In my analysis, I use several measurements of student performance as outcome variables. My main outcome variable is middle-school GPA.[5] Moreover, I use several alternative test score measures to examine both the robustness and heterogeneous effects of the results. In particular, I examine average grades separately in the core subjects (mathematics, Norwegian, and English) to investigate whether a ban against mobile phones might have heterogeneous effect on different subjects. I further separate grades that are assigned by a student's own teacher and test scores that are externally graded. While middle-school GPA focuses on short-term impacts, I also study students' progression into high school education. Specifically, I investigate whether a ban against smartphones in schools affects the type of high school track in which students enroll. For this, I construct a measure for whether students attend an academic or vocational program. High school program choice is associated with long-term education and labor market outcomes (Hanushek et al. 2017) and thus captures a broader set of skills and aspirations compared with test scores.

Importantly, the registry data allow me to test whether the introduction of a smartphone ban changes the composition of the school intake in terms of student, school, and teacher characteristics. By linking the employer–employee registry with the education registry, I construct teacher and principal characteristics at the school level, including type of education, years of experience, and gender ratio.

3.2 Pupil survey

The Norwegian Education Act, §9 A-9, states that each school is responsible for providing a safe environment for children. Thus, strict measures have to be taken against any form of bullying at school, such as physical or mental harassment, regardless of whether it occurs online or in person. The Norwegian Directorate for Education and Training administrates an annual national Pupil Survey which students are asked about bullying, learning, and social well-being in school. The answers are generally used by the schools, the municipality, and the central government to improve the schools. Participation in the survey is compulsory for all schools. The survey is conducted in grades 7, 10 and 13, the last year of high school (Utdanningsdirektoratet 2020*a*). As the Pupil Survey contains unique school identifiers for each school, I can link the survey data to the registry data as well as other school-level data.

The data from the Pupil Survey are aggregated at the school level and are available for years 2007–2019. The exact questions vary across years. However, four areas are consistently covered each year: (i) whether students have experienced bullying, (ii) their level of motivation,

[5] All grades standardized by cohort, with a mean of zero and standard deviation of one.

(iii) their social well-being, and (v) pupil democracy. The responses are measured on a scale from 1 to 4 for bullying, with a value close to one being desirable as it represents low levels of reported bullying. Motivation, social well-being, and democracy are measured on a scale from 1 to 5; a high value is desirable and expresses better circumstances in terms of these variables.

Bullying is defined as repeated negative actions by one or more person/s, against a student who may have difficulty defending him- or herself. It can be calling another person mean names and teasing them, holding a person off, talking behind their backs, pushing, or hitting. The measurement of bullying is based on students' answers to several specific questions concerning whether they themselves have been exposed to these kind of actions, with responses varying from "not at all" (1) to "several times a week" (4). I use this composite variable to measure bullying. Questions regarding motivation refers to students' inner motivation. Students answer questions relating to how interested they are in learning at school, how much they like school work, if they look forward to going to school, if they prioritize school work during lectures, and at home and whether they are motivated to work even if they find the subject difficult. Students provide answers on a scale from "completely disagree" (1) to "completely agree" (5). For social well-being, students answers questions concerning whether they thrive at school, with answers ranging from "completely disagree" (1) to "completely agree" (5). For pupil democracy, students answer questions related to whether the school listens to students' suggestions. Similar to motivation and social well-being, this question is answered on a scale from "completely disagree" (1) to "completely agree" (5). These three variables are used to evaluate mechanisms that might explain the results for educational outcomes and bullying. All variables are reported as the mean among students in grade 10 at school and by gender. Answers from grade 10 students are selected because this is in the year in which the middle-school GPA is also measured. To assist interpretation, I standardize these variables to have a mean of zero and a standard deviation of one at the yearly level.

3.3 School smartphone policy data

The identification strategy that I use relies on comparing the outcomes of cohorts with variations in treatment exposure to smartphone bans at different schools. This requires knowing the exact year in which each school implemented a ban regulating smartphone usage during school hours. As noted above, schools are free to set their own policy regarding smartphones and other electronic devices in the classroom. As there are no centrally collected data on school policies regarding electronic devices, I collected data on mobile phone policies by sending out a short online survey to all middle schools in Norway in 2019. In total 1,250 middle schools received the survey via an email directed to the principal of each school. The survey contained questions about the school's current policy regulating students' phone usage and the year in which any smartphone policy was introduced. The full questionnaire is provided in the Appendix A. Questions regarding the type of policy and how strict it is were also included in the survey. A total of 529 schools had answered the survey by March 2020, for a response rate of 42.3%.

3.4 School and municipality level data

I use several supplementary data sources. As my analysis period includes the financial crisis, I control for the unemployment rate in a robustness check. Given that Norway is an oil-producing country, the unemployment level fluctuates with the price of oil. For example, in 2016, unemployment increased to 5% following the decline in the price of oil (Cappelen et al. 2016). I use data on the municipality-level unemployment rate provided by the Norwegian Center for Research Data to control for the level of unemployment at the municipality level. Additionally, I obtain data on the number of PCs per students in each school for the years 2003–2013 from the Norwegian Directorate for Education and Training. I use this data as a baseline characteristic for technological adaptation at school when performing the heterogeneity analysis and to make predictions when a schools introduces smartphone bans. The data on municipality-level unemployment and PCs per student are linked to the registry data using municipality and school identification numbers.

3.5 Descriptive statistics

Figure 1 plots the number of schools introducing a ban against smartphones in a given year. The figure documents that bans against smartphones in middle schools were unusual before 2010. After 2010, bans were introduced at an increasing rate, with the number of implemented bans peaking in 2016, when 96 middle schools implemented a ban. I define middle schools as having a strict phone policy if they either (i) ask students not to bring their phones to school or (ii) collect phones before lectures and store them in a "mobile phone hotel". Between 30–50% of the schools that implemented a ban each year have strict smartphone policies. As shown in Figure 2, it is most common for schools to allow students to use their phones under certain conditions to use their phones, as long as it does not distract the class.

The left-hand y-axis of Figure 1 shows that the ownership of smartphones/mobile phones is very common among adolescents in Norway. The average ownership rate is above 95% for adolescents aged 12–16 years. In comparison, computer ownership among adolescents is much lower, with only 70% having their own computer (Medietilsynet 2020). Survey evidence from Norway indicates that more than 60% of all teenagers in grade 10 spend 2 or more hours on their phone each day. However, the difference by gender is large. More than 70% of girls answered that they spend 2 or more hours on their phone each day, compared with only 54% of boys. The gender difference by social media use is even larger: 60% of girls spend 2 or more hours on social media per day, compared with only 32% of boys (Medietilsynet 2018).

The high ownership rate for smartphones among Norwegian adolescents is not surprising given that Norway is one of the most advanced countries in the world in terms of consumers adopting digital media and technological implementation. Despite its many remote areas and the mountainous landscape, as early as 2007, 90% of the Norwegian population had access to 3G-coverage, as documented in Figure 3. By 2015, 4G-coverage was fully available for the Norwegian population. Despite not having individual-level data on smartphone usage, these aggregated numbers show that school regulations targeting smartphones affect most adolescents and impact individuals' smartphone usage during school hours.

My baseline data set contains 151,925 observations. I do not make any sample restrictions except that I include only individuals who attend a middle school with a known smartphone policy and individuals for whom I can observe middle school GPA and test score data in grade 5. Table 1 compares the average characteristics and outcomes of individuals in schools where I was able to obtain information on the smartphone policy to average for individuals attending schools where information is lacking. Comparing standardized test scores, we see that sampled schools have, on average, a somewhat higher GPA and that pupils' parents have slightly higher incomes and education. However, there is no difference in bullying experience, or gender balance between students in responding versus nonresponding schools. While this limits the external validity of my results, these differences pose no threat to my identification strategy that focuses on schools participating in the survey.

4 Identification Strategy

To investigate how students educational outcomes and bullying are affected by a ban against smartphones, I rely on a difference-in-difference approach. I exploit variation within-school and cross-cohort differences in exposure to smartphone bans induced by the timing of schools autonomous phone regulation decisions. Although a smartphone ban might have an immediate impact on student outcomes, its effect on students' educational outcomes and experience of bullying could vary over time for two main reasons. First, some cohorts of students are only exposed to a ban for part of their middle-school years. This might generate time-varying treatment effects based on the length of exposure to the policy. Second, the ban itself might have time-varying impacts on local school conditions, norms over phone usage, and resources allocated to students, such as teachers' time and effort. Therefore, the effect of a ban might different in the first, second, or third year after its introduction. To allow for such time patterns, my main empirical strategy is an event-study model that nonparametrically traces out these time-varying treatment effects.

To estimate unbiased effects, the timing of a school adopting a smartphone ban needs to be uncorrelated with other determinants of student outcomes. I start by presenting evidence from an empirical test to support this key identification assumption. To test for this, I study whether school, student, and teacher characteristics can predict the implementation of a smartphone ban. Table 2 presents estimates for η in the following equation:

$$Year_s = \eta X_{s,c0} + \pi_f + \chi_s \tag{1}$$

where $Year_s$ is a dummy variable for whether a school s implemented a ban before 2013, 2015, or 2017. $X_{s,c0}$ is a vector of pre-ban school-level characteristics for schools, students, and teachers measured in 2007; 2007 is prior to the introduction of smartphone bans for the vast majority of schools and is also the first year when measurements of bullying are available. In particular, Column (i) to (iii) in Table 2 show that student characteristics during the time period of interest fail to predict when a smartphone ban is introduced. Importantly, neither students' performance, the share of students later attending an academic high school track, nor bullying can predict when a school implements a smartphone ban. Moreover, the results do not indicate that teacher characteristics, such as sex ratio, education, and experience predict an early implementation of a smartphone ban.

Second, I examine whether the timing of the introduction of smartphone ban was correlated with changes in student, school, and teacher characteristics using Equation 1 . This could be the case if, for instance, smartphone bans were implemented earlier in schools that had declining average GPA or increased bullying levels. The results are presented in Columns (iv) to (vi) in Table 2. There does not appear to be a significant correlation between the timing of the implementation of a smartphone ban an changes in student, school, and teacher characteristics from 2007 to 2010. The only exception is that schools with a larger share of female teachers are more likely to implement a ban early. Controlling for the share of female teachers at schools does not change my main results. Altogether, there seems to be a lack of systematic correlation between when schools implement a ban and both the level of and changes in students' socioeconomic, school, and teacher characteristics, as well as technological adoption at schools.

4.1 Event-study specification

My empirical strategy exploits the staggered adoption of smartphone bans between schools within a flexible event-study framework in a manner similar to Bailey & Goodman-Bacon (2015). Formally, for individual i, who is in cohort c and attending middle school s:

$$Y_{ics} = \alpha_0 + \lambda_s + \theta_c + \gamma X_{ics} + \sum_{y=-4}^{-2} \psi_y D1(c - T_s^* = y)_{is} + \sum_{y=0}^{5} \psi_y D1(c - T_s^* = y)_{is} + \epsilon_{ics} \quad (2)$$

where Y_{ics} is the reduced form outcome of interest (GPA, various test score measures, or the probability of attending an academic high school track). λ_s is a set of school fixed effects that absorb time-invariant differences between schools. This allows for consistent estimates of ψ even in the presence of unobserved differences between schools. The cohort fixed effect, θ, controls for common time-specific shocks within cohorts that might be correlated with the introduction of a smartphone ban or educational outcomes.

X_{ics} is a set of individual and family characteristics, including the individual's gender, parental background characteristics, such as the mother's education and income, mother's age and marital status at birth, and father's education and income, father's age at birth, the individual's birth order, a dummy for whether individual i is 1 year older than his or her peers, and a dummy for whether individual i is 1 year younger than his or her peers. In a robustness check, I additionally control for the yearly unemployment rate at the municipality level, as the time period considered includes the years 2007–2008 when the financial crisis emerged, and the decline in the price of oil from 2014. These factors have little effect on my results.

D_s is a binary indicator for treatment that is equal to 1 from year T_s^*, which is when a school implements a ban. The event-year dummy, $1(c - T_s^* = y)$, is equal to the number of years of exposure that a cohort has to a smartphone ban, with c being the cohort and T_s^* being the implementation year of the smartphone ban at school s. For example, a cohort that finishes middle school in 2018 and is attending a middle school that adopted a smartphone ban in 2017 will have an exposure time of 1. On the other hand, a cohort that finishes middle school in 2015 and is attending a middle school that adopts a smartphone ban in 2018 will have an exposure time of –3. As middle school is 3 years, cohorts with an exposure time of 3 are the first cohort to be fully exposed to a smartphone at middle school s.

The ψ estimates measures the intention-to-treat (ITT) effects of the smartphone ban on students' educational outcomes. In the regression, ψ_{-1} is omitted such that all ψ estimates are relative to the year prior to the smartphone ban adoption. Observations more than 4 years before or 5 years after the mobile phone ban is implemented are captured by dummies $1(c - T_s^* = -4)$ and $1(c - T_s^* = 5)$.[6] Standard errors are clustered at the school level.

The ψ coefficient nonparametrically captures pretreatment relative trends (ψ_{-4} to ψ_{-1}) before a smartphone bans was implemented, as well as time-varying treatment effects (ψ_0 to ψ_5). ψ_{-4} to ψ_{-1} allow for a direct evaluation of the assumption that cohorts at schools implementing a smartphone ban would have had the same outcomes as other cohorts at schools without a smartphone ban in the absence of the ban. If there are any pretreatment trends before the introduction of a smartphone ban, this would suggest a deviation from the secular trends. In other words, the design allows me to evaluate directly whether the timing of the ban is uncorrelated with other determinants of student outcomes.

Conditional on the control variables, the variations arise from two sources. The first is within-school differences in exposure by different cohorts driven by the schools' decision and implementation of a ban. The second source of variation comes from cross-school differences in the timing of adopting smartphones bans.

Including previous test score results changes the interpretation from the change in test scores in Equation 2 to individual i's gain in test scores.

$$Y_{ics} = \alpha_0 + \alpha_1 Y_{ics-1} + \lambda_s + \theta_c + \gamma X_{ics} + \sum_{y=-4}^{-2} \psi_y D1(c - T_s^* = y)_{is} + \sum_{y=0}^{5} \psi_y D1(c - T_s^* = y)_{is} + \epsilon_{ics} \tag{3}$$

Y_{ist-1} represents individual i's national exam test score in grade 5 and accounts for ability, family, and school investment up to grade 5. Below, I first show estimates without controlling for previous test scores to evaluate whether there was an increase in test scores. Then, I show estimates controlling for previous test scores to evaluate the gain in test scores after smartphones were banned.

In contrast to GPA, test scores and the probability of attending an academic high school track, bullying is measured at the school level. I use the same event-study model as in Equation 2 but on school level to estimate the effect of banning smartphones on incidents of bullying.[7]

[6] I choose this event-year window because the sample size is small beyond these values. Note that the binned endpoints are –4 and +5 and that I show estimates from –3 to +4. End point results are not shown in the graphs as they are a combination of several event-years and as such, should not be interpreted as treatment effects (Bailey & Goodman-Bacon 2015).

[7] I also estimated this equation using the methodology of Abraham & Sun (2018) and Novgorodsky & Setzler (2019) to optimize the number of control groups using a "stacked" approach. This approach matches

Formally, I regress the following equation for school s and year t:

$$Y_{st} = \alpha_0 + \lambda_s + \theta_c + \gamma X_{st} + \sum_{y=-4}^{-2} \psi_y D1(t - T_s^* = y)_s + \sum_{y=0}^{5} \psi_y D1(t - T_s^* = y)_s + \epsilon_{st} \quad (4)$$

where Y_{st} is a standardized indicator for bullying. For the school-level analysis, I include the average test scores for students in grade 5, together with the average income, education, age, and marital status of mothers and fathers, and the share of one-year older and one-year younger students in X_{ics}. The estimates are weighted by the number of pupils, and standard errors are clustered at the school level.

Another identification problem is the existence of alternative school-cohort-specific policies or events, such as changes in leadership at school, that were implemented concurrently with the smartphone ban and might impact student outcomes. To address this issue, I add a dummy variable controlling for whether an individual is exposed to a leadership change during middle-school years. This allows me to account for the time-varying characteristics of the school.[8] Additionally, as the previous literature has shown, peer effects appear to be an important determinant of students' own achievements (Burke & Sass 2013). Therefore, I control for peers' previous achievements measured by peers' test scores in grade 5.

Moreover, if the characteristics of new students change post-ban, despite the fact that students are assigned to middle schools based on fixed catchment areas, this might change the school environment and alter student test scores and well-being. Even though the estimated effects could be interpreted as the total policy impact in a partial equilibrium, the aim of this paper is to estimate the effect of a phone ban on students' educational outcomes and bullying. Therefore, I test whether the characteristics of students or teachers change relative to the introduction of a smartphone ban. The results of this exercise are shown in the Appendix A.2. Conditional on school and cohort fixed effects these figures show that there is little evidence that student intake or teachers' characteristics changed post-ban. The only exception is a decrease in the share of employees with a teaching degree and an increase in the share of students with foreign-born parents. In my main results, I control for these factors. Note that both of

all possible control observations to any given treatment observation at any time.

[8] To my knowledge, there were two countrywide policies implemented during the time period considered; the teachers' norm and a homework policy. The teachers' norm was policy implemented in 2018 with the goal of restricting the student-to-teacher ratio to 20 (Utdanningsdirektoratet 2019*b*). The homework policy was implemented in 2014 for grades 1–10. In particular, it required that each school provides 8 hours a week for homework assistance, with this time divided between grades 1–10 (Utdanningsdirektoratet 2019*a*). As both policies were nationwide, they are absorbed by the cohort fixed effects.

these trends would likely reduce the potential positive effects of a smartphone ban, as these figures indicated a decrease in formal pedagogical competence among the staff and an increase in students who, on average, have lower grades in middle school (Statistics Norway 2020). Importantly, there is no trend in previous achievement or in the intake of number of students.

4.2 Alternative specification

To test for the robustness of my research design, I complement the event-study analysis with an alternative specification to test the joint significance of the event-study estimates in a difference-in-difference specification. I replace the individual event-year indicators of Equation 3 with indicators for groups of event-years in three categories. In particular, I estimate the model:

$$\begin{aligned} Y_{ics} = \beta_0 + \beta_1 Y_{ics-1} + \lambda_s + \theta_c + \gamma X_{ics} + \beta_2 Ban_{ics}\mathbf{1}[c - T_s^* \leq -2] \\ + \beta_3 Ban_{ics}\mathbf{1}[0 \leq c - T_s^* \leq 2] + \beta_4 Ban_{ics}\mathbf{1}[c - T_s^* \geq 3] + \epsilon_{ics} \end{aligned} \tag{5}$$

Here, β_2 subsumes the impact up to 2 years before the introduction of a smartphone ban, β_3 captures the short-run impact, and β_4 captures the impact for individuals who are exposed to a ban for all 3 years of middle school. The coefficients are ITT effects. Similar to before, X_{ics} is a set of individual and family characteristics that also includes peer achievement and a dummy for leadership change. Additionally, I run Equation 5 with pre-reform trends for the outcome of interest. I estimate a school-specific trend using data before a ban was introduced, obtaining a slope coefficient τ for each school. Then, I extrapolate the pre-expansion time trends to the post-reform period as follows:

$$\begin{aligned} Y_{ics} = \beta_0 + \beta_1 Y_{ics-1} + \lambda_s + \theta_c + \delta\tau_s + \gamma X_{ics} + \beta_2 Ban_{ics}\mathbf{1}[c - T_s^* \leq -2] \\ + \beta_3 Ban_{ics}\mathbf{1}[0 \leq c - T_s^* \leq 2] + \beta_4 Ban_{ics}\mathbf{1}[c - T_s^* \geq 3] + \epsilon_{ics} \end{aligned} \tag{6}$$

I include the slope coefficient τ as a linear pretreatment trend.

5 Empirical Results

In this section, I first investigate the effects of smartphone bans on educational outcomes. Then, I turn to studying the impacts on smartphone bans on bullying and provide some results on potential mechanisms.

5.1 Educational outcomes

Table 3 shows the estimated coefficients on the impact of a smartphone ban on middle-school GPA and the probability of attending an academic high school track. Columns (i) and (v) of Table 3 represent the results for the most basic specification, which accounts only for parental characteristics, school, and cohort fixed effects. I include one additional confounding factor in each column in Table 3. Columns (iv) and (ix) show my preferred estimations. These estimates include school and cohort fixed effects, while also controlling for parental background, individual characteristics, previous achievement, and peers' achievements; they also include and a dummy variable controlling for leadership change. The year before the event (–1) corresponds to the omitted category and is always zero by construction. I find no meaningful statistically significant effects of banning smartphones on students' middle-school GPA or the likelihood of them attending an academic high school track when examining at the full sample. Figure 4 show estimated coefficients in an event study graph. Three years prior to the ban, there is a positive and statistically significant effect on students attending an academic high school track. As I show, this effect is concentrated on boys for whom there is no effect or detectable trend post-ban. Additionally, as shown in Table 2, the share of students attending an academic high school track is not predictive of when a school implements a ban.

The analysis based on the full sample indicates that there is no effect on students' GPA or the likelihood of progressing into an academic high school track. As such, these GPA results are similar to the finding of Kessel et al. (2020). However, the effect on smartphone bans might not be the same for different groups of students. In recent decades, girls have been outperforming boys in school. In addition, it has been shown that girls and boys react differently to resources in the classroom (Fredriksson et al. 2013, Pekkarinen 2012). Further, phone usage is significantly higher among girls than among boys (Medietilsynet 2018). Hence, girls could be more intensely affected by the ban and, therefore, the potential effect could be larger for girls. Consequently, I present the results separately by gender in Table 4. Section A shows the estimates for girls and section B shows the estimates for boys. Examining the effect on GPA in Column (i) to (iv), its is evident that there is no significant increase, for boys or girls post-ban. Figure 5 (a) illustrates the results on GPA by gender. In the years prior to the ban, the coefficients between female and male GPA are similar, confirming that female and male students share the same trends prior to the smartphone ban. Although, not statistically significant (p-value 0.116) there is a positive upward trend in females' GPA when girls are exposed from the start of their 3-year middle school education.

Columns (v)–(ix) in Table 4 report the results for the effect of the smartphone ban on the probability of choosing an academic high school track by gender. The last year in the education registry is 2018. As such, these results include individuals who finish middle school during or before 2017. For girls exposed to a smartphone ban for at least 2 or more years when they are in middle school, the probability of attending an academic high school track increases by 4–7 percentage points. This result shows that banning smartphones increases the probability of them entering a more challenging high school track, preparing them for further higher education. These estimates are significant at the 5% level. An alternative way of illustrating this magnitude is to compare it with the pretreatment mean: the estimated effect suggests there is a 7–14% increase in the number of girls attending an academic high school track compared with the average number of girls who attended an academic high school track relative to pre-ban years. Visually, the result on the probability of attending an academic high school track by gender can be seen in Figure 5. Although the effect on the probability of attending an academic high school track is only significant for girls, these effects are not statistically different from the estimated effect for boys.[9]

In my survey, approximately 42% of schools responded that phones are prohibited at school or that phones are collected before class and stored in "mobile phone hotels". I define these schools as having a strict smartphone policy. Schools that allow phone use during the breaks are defined as schools with lenient policies. To disentangle the effect between these schools, I separately examine the educational outcomes by type of policy. Figure 6 displays the results. In the years prior to the ban, the coefficients between girls at schools with a strict and lenient policy are similar, confirming that girls at these schools share the same trend prior to the smartphone ban. By contrast, after a ban has been introduced the gain in GPA diverges between girls attending a school with a strict and a lenient policy toward smartphones. Girls attending a middle school with a strict policy have significantly higher GPA 4 years post ban and gain 0.10 of a standard deviation in GPA (p-value 0.088) . However, I cannot reject the null hypothesis that these two coefficients between girls attending schools with strict and lenient policies are different. There are no detectable differences on the likelihood of attending an academic high school track between school with strict compared with more lenient policies.

These results show that educational outcomes for girls are improving after smartphone ban in school, whereas boys are not affected. This suggests that the gender gap in education might increase following the introduction of smartphone bans in middle school. That fact that there are no significant negative effects for boys implies that there are no negative externalities from

[9] Note that the positive effect on attending an academic high school track 3 years prior to the introduction of a smartphone ban is driven by boys, for whom there is no effect post-ban.

smartphone use on boys.

My results show that girls have to be exposed to a ban for at least 2 years for any significant impact on educational outcomes to be observed. The lack of an immediate effect could be due to the fact that it takes time to establish new norms around smartphone use, or it could be that the lower human capital accumulation in the period before the ban cannot be compensated for in the short run.

A large literature suggests that family background and school environment characteristics are important traits for student achievement (Björklund & Salvanes 2011). One important dimension is the parents' socioeconomic status. To disentangle the effect between students of low and high socioeconomic status, I separately examine individuals whose fathers have an academic or vocational high school education. Figure 7 shows the results. Girls whose fathers have a vocational education experience the largest gain in GPA. Three and four years post-ban, these girls gain 0.09-0.11 standard deviations in GPA (p-values of 0.053 and 0.032, respectively). Additionally, girls with vocationally educated fathers are 5 percentage points more likely to attend an academic high school track 3 years post ban and 6 percentage points more likely 4 years post ban (p-values of 0.056 and 0.071, respectively). There is no effect on boys' GPA or their probability of attending an academic high school track. These important differences suggest that unstructured technology is especially distracting for girls from low socioeconomic families, whereas girls from high socioeconomic families or boys do not experience any negative externalities.

To investigate whether the effects of smartphone bans are equally distributed along students' ability, I divide students into four quartiles based on prior school achievement in grade 5 (primary school). Group one consists of students with the lowest ability and group four consists of students belonging to the top of the ability distribution. Figure 8 shows the results. There is no effect on either girls or boys GPA, independent of ability. I conduct the same exercise by quartiles on the probability of attending an academic high school track. The results are shown in Figure 8. Girls in the first and second quartiles, the two lowest quartiles, are significantly more likely to attend an academic high school track when they are exposed to a smartphone ban for 2–4 years. In particular, girls in the lowest quartile are 11 percentage points more likely to attend an academic high school track 4 years post-ban (p-value 0.034). Girls in the second quartile are at most 10 percentage points more likely to attend an academic high school track (p-value 0.029). Note, however that the estimates for different ability groups are not statistically different from each other. Boys are not significantly impacted.

The existing literature has found indications that teachers can be biased toward their own students (Terrier 2020, Carlana 2019, Lavy 2008). If students behave better after a smartphone policy is in place, a teacher could potentially award students with a higher grade even if they have made no actual improvement in grades. As the Norwegian Registry data contain not only grades set by the teachers, but also externally graded exams, I test whether there is an improvement in blind test score. First, I examine grades set by the students' own teachers. I use both the weighted average across subjects and the grade for each of the three main subjects: Norwegian, English, and mathematics. The results are shown in Figure 9. Four years post-ban girls, gain 0.07 standard deviations in test scores set by their own teacher (p-value 0.088). Separating grades by field, post-ban test scores set by teachers in Norwegian increase for girls between 0.08 (p-value 0.047) and 0.12 standard deviations (p-value 0.020), as documented in Figure 10. Like for girls, boys test scores in Norwegian increases by 0.08 (p-value 0.069) and 0.12 (p-value 0.046) standard deviations.

Similarly, blind test scores are reported for the subjects Norwegian, English, and mathematics. Figure 11 documents these results. Girls have significantly higher test scores in mathematics 4 years post-ban. The gain in mathematics is 25% of a standard deviation (p-value 0.007). The substantial increase in externally graded test scores in mathematics for girls suggests that the ban improved human capital accumulation. Moreover, there is survey evidence indicating that girls are feeling more anxious about mathematics compared with boys (OECD 2013). One could speculate that during mathematics lectures girls are more likely to turn to non-study-related activities on their phone if they struggle with the task and start feeling anxious. When phone usage is prohibited, they are required to focus on the subject.

The general level of technological adoption at school might be an important dimension of how bans are implemented and enforced. If more technologically advanced schools generally use technology more frequently in the method of instruction, the effect of banning smartphones might not be the same as for students at these schools as that for individuals at schools with more traditional teaching methods. As schools have some independence in resource use, they can decide how to allocate spending on school and student infrastructure, which includes computers. I divide schools into low- and high-tech schools depending on the number of computers available per student pretreatment. Figure 12 shows the results. There is no difference in GPA between low- and high-tech schools, neither for girls or boys. However, girls at low-tech schools are 13 percentage points more likely to attend an academic high school track 3 years after a smartphone ban has been introduced (p-value 0.036). Four years post-ban, girls at these schools are 16 percentage points more likely to attend an academic high school track (p-value 0.022). There are several reasons for this pattern of results. Differences across schools with higher and lower technology adoption could also arise if the former have established better norms for technology use without necessarily banning phone usage. On the other hand, the lack of the effect in high technology-adoption schools could arise from students substituting away from phones but continuing to consume social media via tablets or laptops during the lectures, or communicating with their classmates rather than concentrating on the teaching.

Overall, the heterogeneity analysis points toward that girls attending middle schools with a strict smartphone policy, low-ability girls and girls from lower socioeconomic backgrounds experiencing the largest increase in middle-school GPA and the probability of attending an academic high school track after smartphones have been banned. Schools with lower technological adoption have the largest increase in educational outcomes post-ban. This suggest that the gains in educational outcomes are largest when students are less distracted by smartphone usage and have less access to other technology.

5.2 Bullying

Thus far, I have evaluated the effect of banning smartphones on students' educational outcomes. Another important dimension of outcomes is students' experience of bullying at school. Bullying has been shown in previous research to be predictive of several long-term health, education, and labor market consequences (Drydakis 2014). Similar to educational outcomes, I examine at the effect separately for girls and boys, in addition to conducting full sample estimates. The data for bullying is aggregated to the school level, but the cohorts and number of schools are the same as for the estimates at the individual level.

When examining the full sample, the estimates show a decline in the incidents of bullying by 0.24–0.31 standard deviation 2–3 years after a smartphone ban is implemented (p-values of 0.081 and 0.102), as documented by Figure 13. Separating the results by gender, shows that girls are driving these results. Girls experience a 0.29 standard deviation decrease in bullying 2 years after a smartphone ban is introduced (p-value 0.067). Girls exposed full-time for 3 years in middle school to a smartphone ban instead experience a 0.43 standard deviation decline in the incidents of bullying compared to unaffected girls.

For girls, there is no diffrence depending on the type of policy being implemented. However, boys attending a middle school with a strict smartphone policy experience a decline in the incidents of bullying 2 years after the ban is introduced by 0.35 standard deviations (p-values 0.070). However, for boys attending a middle school with a lenient smartphone policy, there is no statistically significant effect, as documented in Figure 14. Although the estimates are not significantly different, this suggests that stricter smartphone regulations that include phone bans during breaks, not just during classes, have a larger preventive impact on bullying for boys.

As the bullying data are on the school level, I cannot study differences by socioeconomic status at the individual level. Nevertheless, I divide schools at the mean based on students with fathers educated at academic high schools. The results are shown in Figure 15. Boys attending low socioeconomic schools experience a decline in bullying by 0.8 standard deviations 2 years after a ban is being introduced (p-value 0.096). There is no significant effect on bullying depending on the socioeconomic status of the school for girls.

Heterogeneity in the results by technological adoption levels at schools are displayed in Figure 16. Boys attending schools with higher technological adoption experience a decline in bullying by 0.84–1.3 standard deviations when they are exposed for at least two years in middle school (p-values 0.034 to 0.053). This suggest that the decline in bullying is largest when students have less access to other technology.

6 Robustness Checks

In this section, I explore whether my main results are robust to the alternative specifications outlined in Section 4.2, perform a number of specification checks, and examine whether other dimensions of student life are affected. My main results are robust to a battery of specification checks, such as grouping the event-years together, excluding parental background characteristics and excluding observations from the capital of Norway, excluding private schools and controlling for the level of unemployment at each municipality.

Table 5 shows the GPA results and the probability of attending an academic high school track when grouping event-years together. Columns (i) and (ii) show the baseline specification. Similar to the event-study specification, the estimated effects on GPA are not significant using this specification. However, the probability of attending an academic high school track increases by 5 percentage points for girls who are exposed to a smartphone ban for 3 years or more (p-value 0.004). Columns (iii) and (iv) include a linear pretreatment trend. This decreases the magnitude of the estimate for 3 years post ban to 4 percentage points (p-value 0.024) .

Table 6 shows the results for bullying when grouping the event-years together. Bullying decreases by 0.23 standard deviations overall, and for girls who are exposed to a ban for 3 years or more to 0.25 standard deviations. This estimate is significant at the 10% level. The significance of these estimates disappears when including a linear pretreatment trend.

Furthermore, I evaluate whether the results are sensitive to including parental background characteristics. Excluding parental background characteristics has no effect on educational outcomes, as shown in Figure 17 and Figure 18.

Additionally, the results are not sensitive to dropping schools situated in Oslo, the capital of Norway. This suggests that the results are not driven by Oslo, the largest city in the sample. Figure 19 and Figure 20 show the results when Oslo is dropped for educational outcomes and bullying. However, when dropping Oslo there is a positive impact on girls' middle-school GPA 4 years after a ban is being introduced. This point estimates was on the margin of being significant in the main specification (p-value 0.116).

From 2007 to 2009, the unemployment rate in Norway increased from 2.5% to 3.8% following the 2008 financial crisis. From 2014 to 2016, the unemployment rate increased from 3.4% to 5.0% following the decline in the price of oil (Eurostat 2020). Although I include cohort fixed effects that should control for any unobserved differences between cohorts – such as certain cohorts being differentially affected by the financial crisis – as an additional check, I control for the unemployment rate at the municipality level to account for differences in local exposure to these economic downturns. Doing so has little effect on the results as seen in Figure 21 and Figure 18.

Less than 1% of the schools in my sample are private schools. Private schools might be very different from public schools in many dimensions, and parents have to apply to these schools for their children to attend. Dropping private schools from the estimates has no impact on my main results, as shown in Figure 23 and Figure 24.

As a last check, I evaluate the banning of smartphones along three other dimensions: (i) social well-being, (ii) motivation, and (iii) pupil democracy. Results for both girls and boys are shown in Figure 25. Social well-being measures how well students like and enjoy school, and motivation measures their level of inner motivation toward school and school work. There is no change in social well-being or motivation post-ban. Similarly, there is no change in the experience of pupil democracy at school post-ban. Overall, this suggests that smartphone bans do not affect social well-being, motivation, or pupils' decision-making, whereas they do lower bullying incidents and improve educational outcomes. Hence, smartphone bans do not alter multiple dimensions of student life that should be less affected by less access to smartphones at school.

7 Discussion

In this section, I compare my results to estimates in the previous literature concerning the magnitude of changes in student outcomes in response to other school-level policies.[10] However, these comparisons must be treated with caution owing to obvious differences in context and research design between studies.

Banning smartphones from school is a policy with relatively small monetary costs, although

[10]Comparing the estimated effects of bullying with those from the previous literature is difficult as, to my knowledge, no other studies have examined the causal effect on bullying.

the enforcement of a ban could be costly if it consumes a great deal of teachers' instruction time. However, the previous literature has evaluated much more monetarily expensive policies, such as introducing computers in classrooms or reducing the number of students in a class. There is a large literature on the reduction of class size (Jepsen 2015, Krueger 2002). Fredriksson et al. (2013) study class size effects in Sweden, a country with a similar education system to Norway. They show that reducing class size among primary school students in Sweden increases test scores in middle school by 0.02 standard deviations. Hall et al. (2019) investigate how the educational performance of middle-school pupils who are given a personal laptop or tablet, is affected in Sweden. They find no effect on student achievement after the introduction of laptops. Barrow et al. (2009) study the effect of a randomized control trial involving the introduction of an instructional computer program for algebra. They find that test scores are 0.25 standard deviations higher among students who use computer-aided instructions. I estimate the increase in middle-school GPA following a smartphone ban to be around 0.09–0.11 standard deviations for girls who are exposed to the ban between 2–3 years with low educated fathers. These effects are larger compared with those of reducing class size by one student. In addition, my results indicates that 4 years after a ban is being introduced, girls gain 0.25 standard deviations in mathematics test scores. This is the same improvement as Barrow et al. (2009) finds in algebra test after students have used instructions program for pre-algebra and algebra.

8 Conclusion

In this paper, I evaluate the effect of banning smartphones from school on students outcomes. Specifically, I focus on how banning smartphones impacts students' GPA, their likelihood of attending an academic high school track, and the incidence of bullying. I combine self-administrated survey data on the timing at which smartphone bans were implementated with Norwegian Registry data and a pupil survey on bullying. My identification strategy is based on the staggered adoption of smartphone bans across schools and time. Importantly for the identification strategy, student, teacher, and school characteristics cannot predict when a school implements a smartphone ban.

My results show that banning smartphones has significant and positive effects on girls' middle-school GPA when schools introduced a strict smartphone policy, and has an overall improvements in their progression into academic high schools, and that it decreases girls' experience of bullying incidents. The average gain in middle-school GPA among girls is 0.10 of a standard deviation at schools with a strict smartphone policy. Bullying decreases 0.43 of a standard deviation for girls exposed to a ban during all 3 years of middle school. In addition, girls are 4–7 percentage points more likely to attend an academic high school track post-ban. The magnitudes of the estimates for the educational outcomes are larger among girls from low socioeconomic backgrounds and for the lowest achievement quintiles, suggesting that these groups of students in particular are distracted by unstructured technology in the classroom. There is no negative effect of banning smartphones on high achieving students or boys. Boys attending a middle school with a strict smartphone ban that restricts them from accessing their phone during lecture hours and breaks experience a decrease in bullying by 0.35 standard deviations. Girls experience a substantial increase in externally graded tests in mathematics, suggesting that the human capital accumulation of girls is improved post-ban.

These findings are not driven by any compositional change among students or teacher or by different parental socioeconomic characteristics at school. My results are robust to a number of specification checks.

Although this paper shows robust evidence of the impact of smartphone bans on student outcomes, because the policy is quite recent, I cannot yet analyze students' likelihood of completing high school, or follow their outcomes in terms of higher education or labor market returns. Nevertheless, it is evident that banning smartphones from the classroom is an inexpensive tool with a sizable effect on student outcomes.

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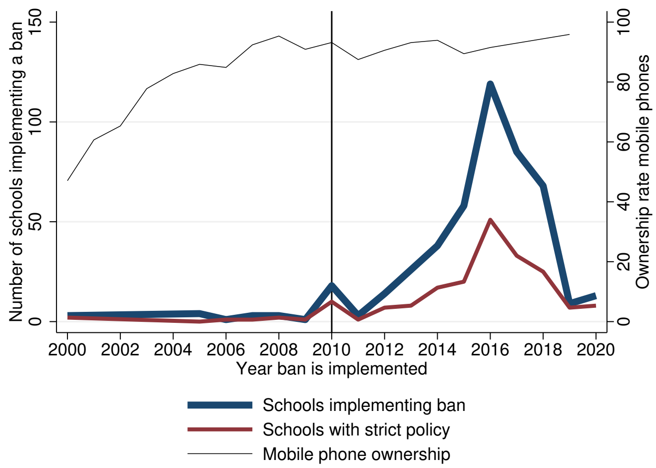
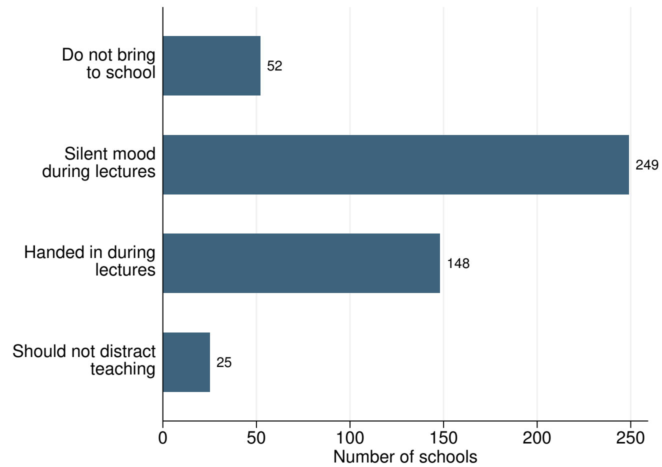
9 Tables and Figures

Figure 1: Introduction of smartphone bans over time at middle schools



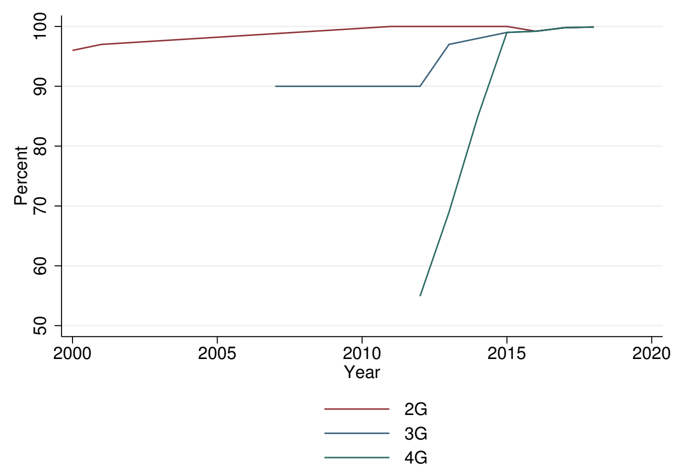
Note: The number of schools implementing a smartphone ban each year. Strict bans against phones are defined as: (i) students are not allowed to bring phones to school, or (ii) phones have to be handed in before the lecture starts and stored in a "mobile phone hotel". Lenient bans allow phone usage during breaks. The vertical line in 2010 indicates the first year that a cohort in my sample starts middle school. *Source smartphone ban*: Own data. The ownership rate of mobile phones is defined for 12–16-years-olds. *Source ownership rate*: Culture and Media Use Survey, Statistics Norway

Figure 2: Type of smartphone ban



Note: Distribution of type of answer by principal. *Source*: Own data.

Figure 3: Proportion of population covered by a mobile network



Source: SDG Indicators, United Nations Statistics Division

Table 1: Descriptive statistics for responding versus nonresponding schools

	All students (i)	Students in non-responding schools (ii)	Students in responding schools (iii)	Difference between column (ii) and (iii) (iv)
	Panel A: Outcome variables at the individual level			
GPA	-0.00	-0.00	0.02	0.03***
	[1.00]	[1.01]	[0.99]	(7.83)
Academic high school track	0.31	0.31	0.31	0.00
	[0.42]	[0.42]	[0.43]	(1.81)
Test score 5th grade	-0.00	-0.01	0.03	0.03***
	[1.00]	[1.00]	[0.99]	(9.56)
	Panel B: Outcome variables at the school level			
Bullying	0.00	0.00	-0.00	-0.01
	[1.00]	[0.99]	[1.01]	(-0.36)
Bullying boys	-0.00	-0.01	0.01	0.02
	[1.00]	[0.98]	[1.01]	(0.81)
Bullying girls	-0.00	0.01	-0.01	-0.02
	[1.00]	[1.00]	[0.99]	(-1.05)
	Panel C: Individual-level characteristics			
Birth year	1999.46	1999.46	1999.45	-0.02**
	[1.65]	[1.65]	[1.67]	(-2.70)
Gender	0.49	0.49	0.49	0.00
	[0.50]	[0.50]	[0.50]	(0.88)
One year older	0.01	0.01	0.01	-0.00***
	[0.09]	[0.10]	[0.08]	(-9.12)
One year younger	0.00	0.00	0.00	-0.00***
	[0.05]	[0.05]	[0.05]	(-3.37)
Birth order	1.87	1.87	1.88	0.01*
	[0.93]	[0.93]	[0.93]	(2.25)
Mothers age	29.05	29.06	29.05	-0.01
	[4.83]	[4.84]	[4.83]	(-0.50)
Fathers age	31.94	31.95	31.86	-0.09***
	[5.71]	[5.74]	[5.70]	(-4.46)
Education mother	13.11	13.09	13.18	0.09***
	[2.46]	[2.46]	[2.46]	(10.05)
Education father	12.74	12.72	12.79	0.07***
	[2.44]	[2.44]	[2.48]	(7.93)
Income mother	385.33	383.25	395.66	12.41***
	[240.75]	[243.01]	[237.37]	(14.78)
Income father	587.24	582.54	613.42	30.88***
	[486.85]	[474.48]	[490.89]	(18.33)
Married	0.92	0.92	0.93	0.01***
	[0.27]	[0.27]	[0.26]	(10.47)
Foreign-born parents	0.08	0.09	0.05	-0.04***
	[0.28]	[0.29]	[0.22]	(-41.46)
Observations	338869	177682	151925	
Number of schools	1736	1232	504	

Notes: Descriptive statistics for key outcome and control variables for all students, students in responding schools, and students in nonresponding schools. Standard deviations are shown in square brackets. Column (iv) shows the difference between students in responding schools versus nonresponding schools over the entire period. T-statistics are shown in parentheses.

Table 2: The effect of school, student and teacher characteristics in the implementation of phone bans

	2007 baseline characteristics		Changes in characteristics baseline between 2007 and 2010	
	Implementing before 2013 (i)	Implementing before 2015 (ii)	Implementing before 2013 (iii)	Implementing before 2015 (iv)
Student characteristics				
Average GPA	0.006	-0.002	0.011	0.023
	(0.014)	(0.018)	(0.011)	(0.015)
Share of students starting at an academic high school track	-0.000	0.062	-0.077	-0.313
	(0.303)	(0.407)	(0.239)	(0.324)
Average income of father\1000	-0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Average income of mother\1000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Share of students with fathers with a post-secondary-education	-0.158	-0.517	-0.267	-0.185
	(0.276)	(0.397)	(0.255)	(0.344)
Share of students with mothers with a post-secondary-education	-0.165	0.164	-0.153	-0.028
	(0.310)	(0.389)	(0.274)	(0.357)
Share of students with foreign-born parents	-0.246	-0.317	0.096	0.395
	(0.500)	(0.535)	(0.413)	(0.593)
School and teacher characteristics				
Number of students	-0.000	-0.001	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.002)
Share of foreign-born students	0.696	0.651	-0.101	-0.153
	(0.630)	(0.782)	(0.176)	(0.321)
Share of female students	0.273	0.739*	-0.004	0.253
	(0.278)	(0.395)	(0.192)	(0.276)
Average experience of teachers	0.002	-0.001	-0.011	-0.007
	(0.006)	(0.008)	(0.008)	(0.010)
Share of female teachers	0.234	-0.053	0.507**	0.233
	(0.175)	(0.231)	(0.237)	(0.317)
Share of employees with a teaching degree	0.079	0.053	0.072	0.128
	(0.220)	(0.295)	(0.282)	(0.415)
Average experience of principal	-0.000	0.000	0.001	0.003
	(0.002)	(0.003)	(0.002)	(0.002)
PCs per student	-0.016	-0.008	0.017	-0.005
	(0.015)	(0.020)	(0.018)	(0.023)
Reported bullying	-0.077	-0.167	0.073	-0.007
	(0.110)	(0.132)	(0.074)	(0.102)
Observations	347	347	347	347
P-value from F-statistics	0.678	0.263	0.403	0.799
R^2	0.089	0.115	0.094	0.101

Notes: School characteristics are measured among students who finished grade 10 in 2007 and among teachers and principals employed during the 2007/2008 school year. The experience of principals and teachers is defined as the number of years employed at any school. The regression controls for county fixed effects. Robust standard errors are shown in parentheses. Significance levels: *** 1% level, ** 5% level, * 10% level.

Table 3: Effects of smartphone ban on student performance, full sample

	GPA				P(Academic track=1)			
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(ix)
-3	0.019	0.002	0.003	0.003	0.031**	0.027**	0.027**	0.028**
	(0.016)	(0.019)	(0.017)	(0.017)	(0.014)	(0.013)	(0.013)	(0.013)
-2	0.001	0.002	0.001	0.001	0.009	0.009	0.009	0.009
	(0.012)	(0.013)	(0.012)	(0.012)	(0.009)	(0.008)	(0.008)	(0.009)
0	-0.005	0.005	0.003	0.003	0.006	0.009	0.008	0.008
	(0.012)	(0.013)	(0.012)	(0.012)	(0.009)	(0.009)	(0.009)	(0.009)
1	-0.017	-0.000	-0.003	-0.003	0.007	0.012	0.011	0.011
	(0.017)	(0.019)	(0.018)	(0.018)	(0.015)	(0.015)	(0.015)	(0.015)
2	-0.006	-0.003	0.001	0.001	0.024	0.026	0.026	0.025
	(0.021)	(0.026)	(0.024)	(0.024)	(0.020)	(0.020)	(0.020)	(0.020)
3	0.011	0.034	0.034	0.033	0.028	0.035	0.034	0.033
	(0.028)	(0.034)	(0.031)	(0.031)	(0.028)	(0.027)	(0.027)	(0.027)
4	0.033	0.058	0.048	0.049	0.031	0.040	0.037	0.036
	(0.036)	(0.044)	(0.041)	(0.041)	(0.035)	(0.034)	(0.034)	(0.034)
Pre-ban mean	0.00				0.41			
Observations	151925	151925	151925	151925	127955	127955	127955	127955
Test score 5th grade		✓	✓	✓		✓	✓	✓
Peer achievement			✓	✓			✓	✓
Leadership change				✓				✓

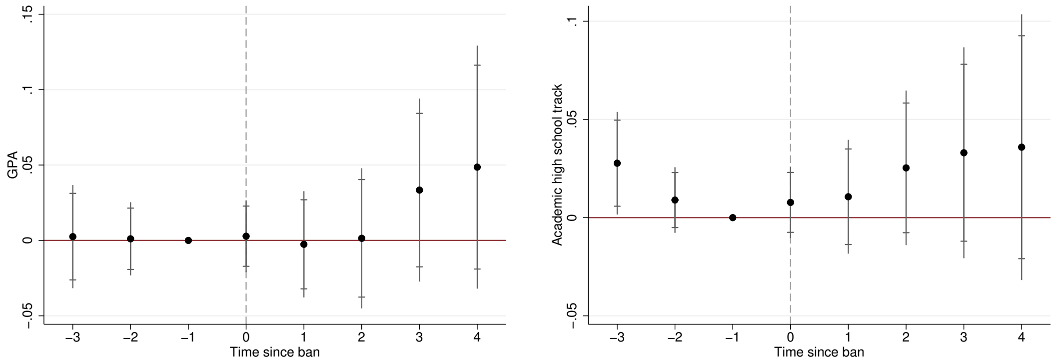
Notes: Columns (i)–(iv) represent regression estimates on student GPA. Columns (v)–(ix) represent estimates on the probability of attending an academic high school track. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level and shown in parentheses. Additional control variables are a dummy variable for gender, mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Significance levels: *** 1% level, ** 5% level, * 10% level.

Table 4: Effects of smartphone ban on student performance, by gender

	GPA				P(Academic track=1)			
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(ix)
					Panel A: Girls			
-3	0.006	-0.010	-0.010	-0.009	0.015	0.012	0.012	0.013
	(0.022)	(0.022)	(0.021)	(0.021)	(0.013)	(0.013)	(0.013)	(0.012)
-2	-0.008	-0.009	-0.010	-0.010	-0.002	-0.002	-0.002	-0.002
	(0.017)	(0.017)	(0.016)	(0.016)	(0.009)	(0.009)	(0.009)	(0.009)
0	-0.012	0.003	0.001	0.000	0.008	0.011	0.010	0.010
	(0.016)	(0.015)	(0.015)	(0.015)	(0.009)	(0.009)	(0.009)	(0.009)
1	-0.042*	-0.011	-0.013	-0.014	0.009	0.015	0.014	0.014
	(0.023)	(0.022)	(0.021)	(0.021)	(0.014)	(0.013)	(0.013)	(0.013)
2	-0.016	0.002	0.007	0.007	0.038*	0.042**	0.042**	0.042**
	(0.029)	(0.028)	(0.026)	(0.026)	(0.019)	(0.019)	(0.019)	(0.019)
3	-0.003	0.041	0.042	0.042	0.050*	0.059**	0.059**	0.058**
	(0.036)	(0.037)	(0.034)	(0.034)	(0.026)	(0.025)	(0.025)	(0.025)
4	0.042	0.076*	0.068	0.067	0.066**	0.073**	0.072**	0.072**
	(0.046)	(0.046)	(0.043)	(0.043)	(0.033)	(0.032)	(0.032)	(0.032)
Pre-ban mean	0.25				0.49			
Observations	75065	75065	75065	75065	63094	63094	63094	63094
					Panel B: Boys			
-3	0.030	0.010	0.012	0.012	0.048***	0.042**	0.043**	0.044**
	(0.021)	(0.023)	(0.022)	(0.022)	(0.018)	(0.018)	(0.018)	(0.018)
-2	0.010	0.012	0.011	0.011	0.020*	0.019*	0.019*	0.019*
	(0.017)	(0.016)	(0.016)	(0.016)	(0.011)	(0.011)	(0.011)	(0.011)
0	0.002	0.009	0.006	0.007	0.004	0.007	0.006	0.006
	(0.017)	(0.017)	(0.016)	(0.016)	(0.012)	(0.012)	(0.012)	(0.012)
1	0.008	0.012	0.010	0.010	0.002	0.006	0.005	0.004
	(0.022)	(0.024)	(0.023)	(0.023)	(0.020)	(0.020)	(0.020)	(0.020)
2	0.003	-0.006	-0.002	-0.002	0.006	0.008	0.008	0.006
	(0.029)	(0.033)	(0.031)	(0.031)	(0.027)	(0.027)	(0.027)	(0.027)
3	0.029	0.032	0.032	0.030	0.005	0.011	0.009	0.008
	(0.037)	(0.042)	(0.039)	(0.039)	(0.036)	(0.036)	(0.036)	(0.036)
4	0.025	0.043	0.035	0.035	-0.006	0.005	0.001	-0.001
	(0.049)	(0.056)	(0.053)	(0.053)	(0.046)	(0.046)	(0.046)	(0.046)
Pre-ban mean	-0.23				0.33			
Observations	76857	76857	76857	76857	64856	64856	64856	64856
Test score grade 5		✓	✓	✓		✓	✓	✓
Peer achievement			✓	✓			✓	✓
Leadership change				✓				✓

Notes: Columns (i)–(iv) represent regression estimates on student GPA. Columns (v)–(ix) represent estimates on the probability of attending an academic high school track. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level and shown in parentheses. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Significance levels: *** 1% level, ** 5% level, * 10% level.

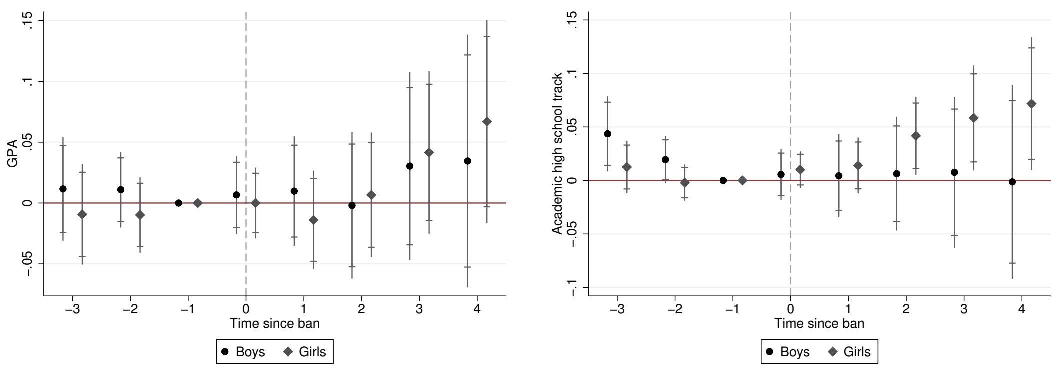
Figure 4: GPA and likelihood of attending an academic high school track



(a) GPA full sample (b) P(Academic track=1) full sample

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are a dummy variable for gender, mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

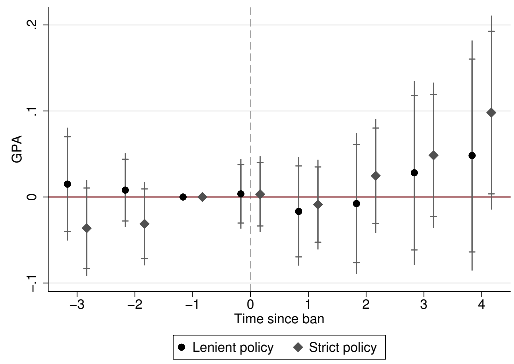
Figure 5: GPA and likelihood of attending an academic high school track by gender



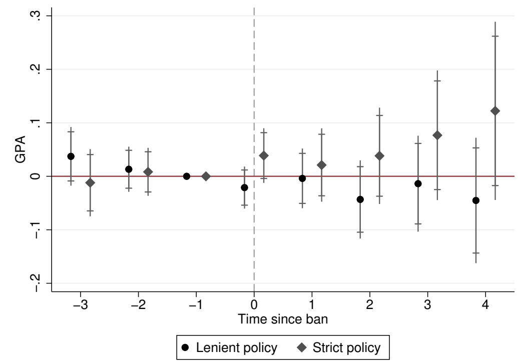
(a) GPA by gender (b) P(Academic track=1) by gender

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

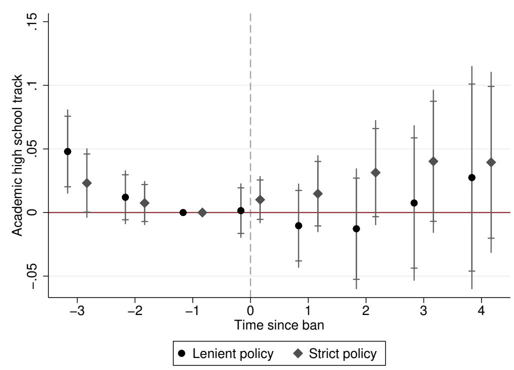
Figure 6: GPA and likelihood of attending an academic high school track by type of ban



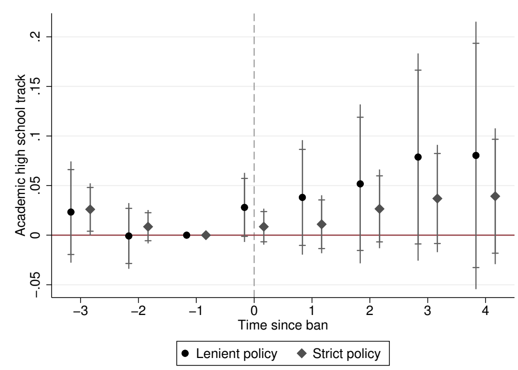
(a) GPA girls



(b) GPA boys



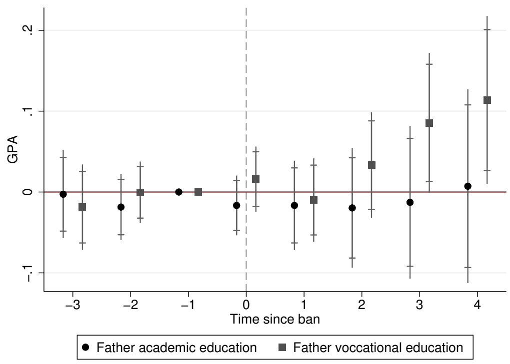
(c) P(Academic track=1) girls



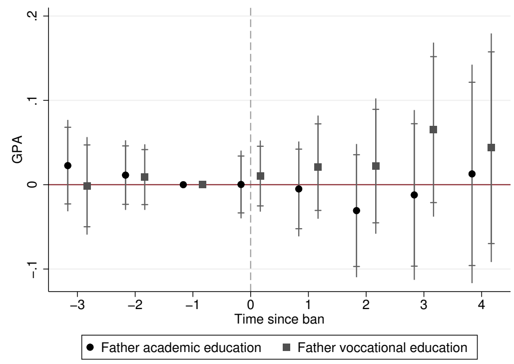
(d) P(Academic track=1) boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

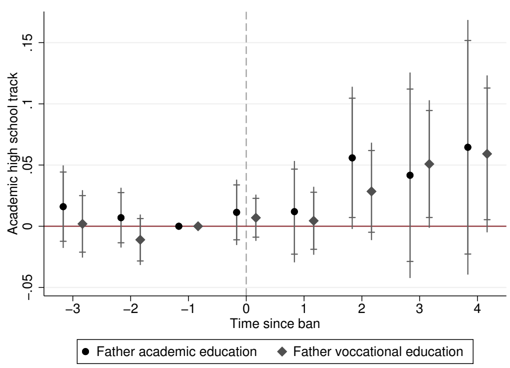
Figure 7: GPA and likelihood of attending an academic high school track by father's type of high school education



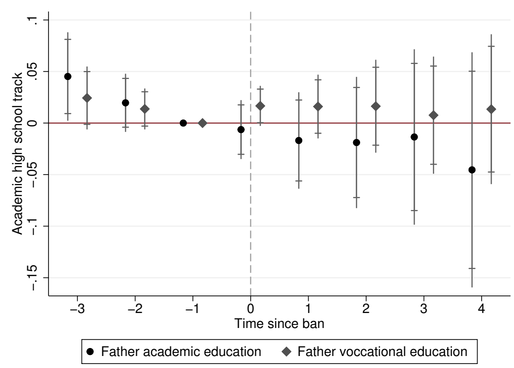
(a) GPA girls



(b) GPA boys



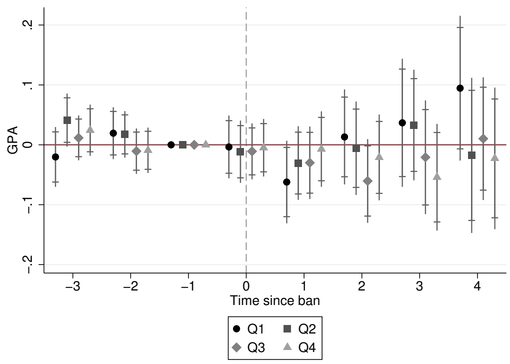
(c) P(Academic track=1) girls



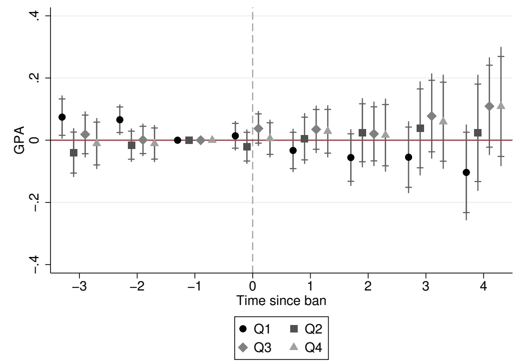
(d) P(Academic track=1) boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

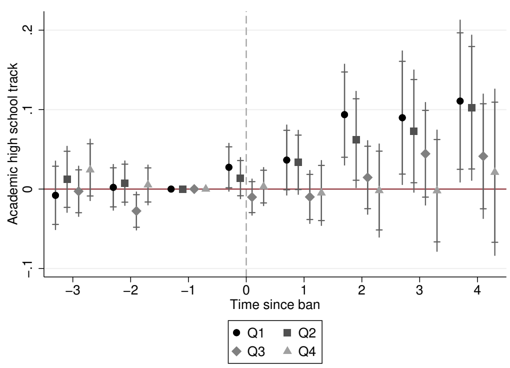
Figure 8: GPA and likelihood of attending an academic high school track by quartile



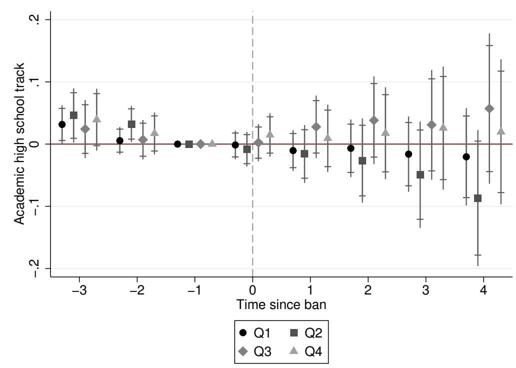
(a) GPA girls



(b) GPA boys



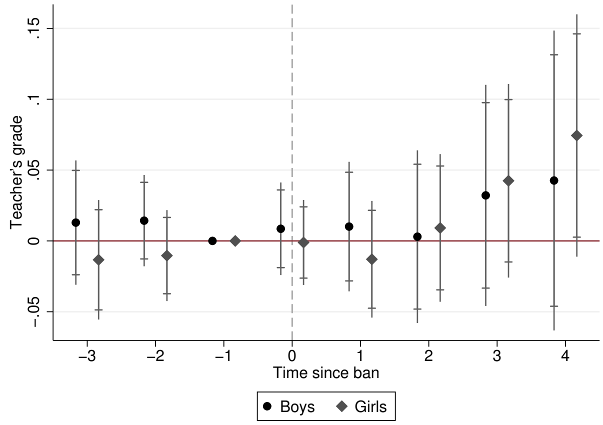
(c) P(Academic track=1) girls



(d) P(Academic track=1) boys

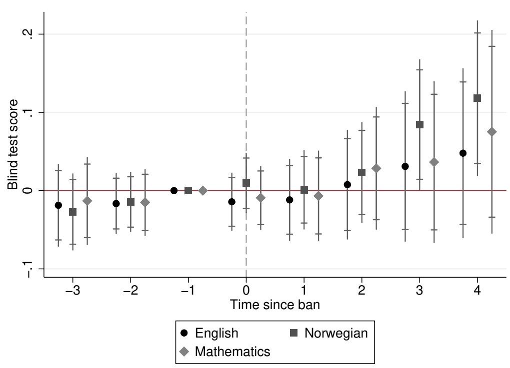
Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 9: Average grades set by teacher

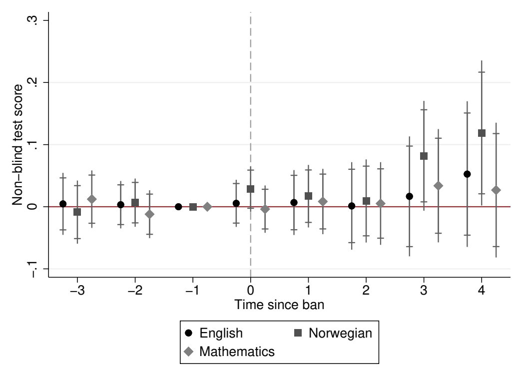


Source: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 10: Non-blind grades



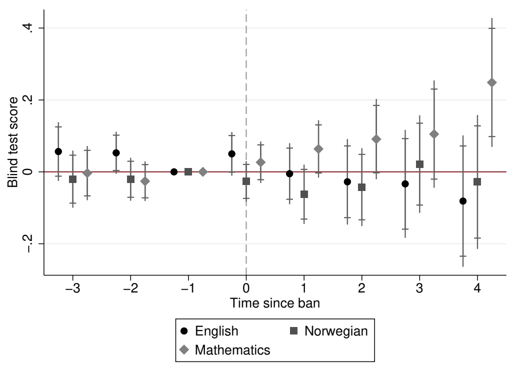
(a) Grades girls



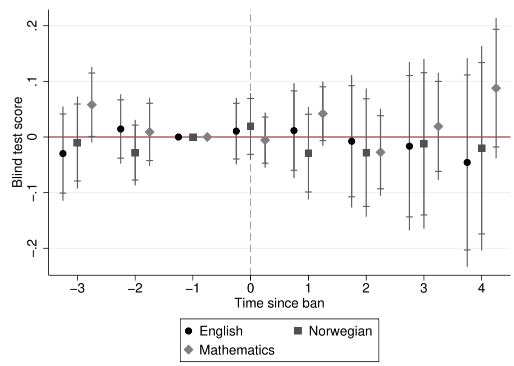
(b) Grades boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 11: Blind test scores



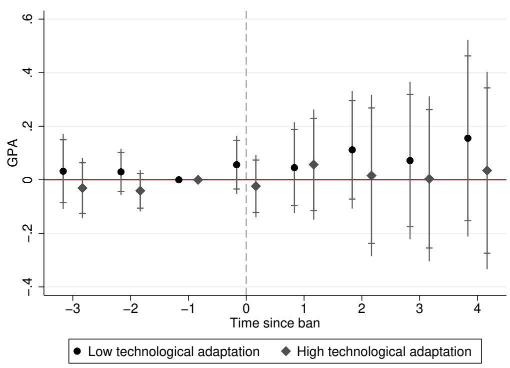
(a) Test scores girls



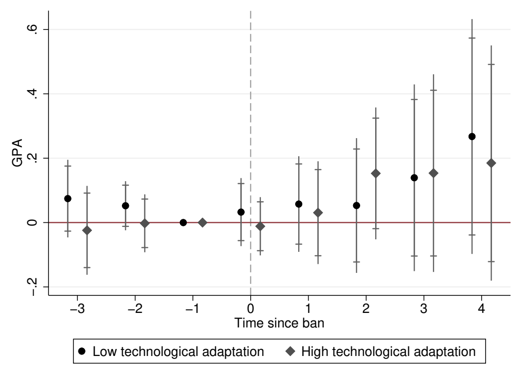
(b) Test scores boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

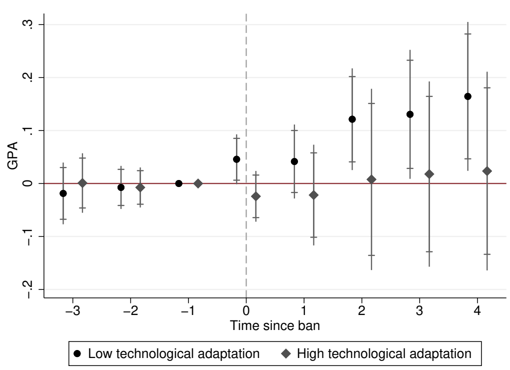
Figure 12: GPA and the likelihood of attending an academic high school track by low- and high-technologically adopted schools



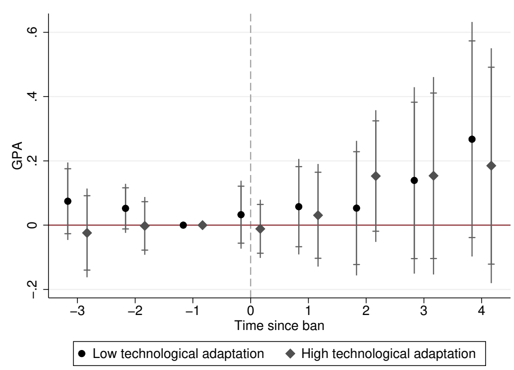
(a) GPA girls



(b) GPA boys



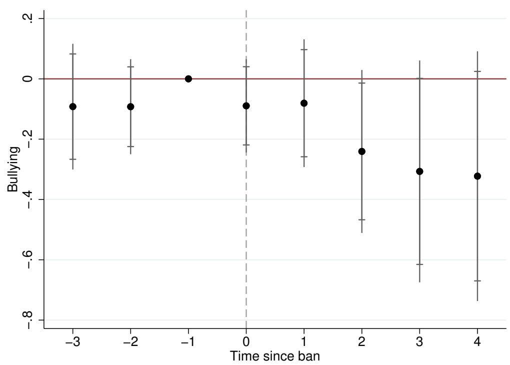
(c) P(Academic track=1) girls



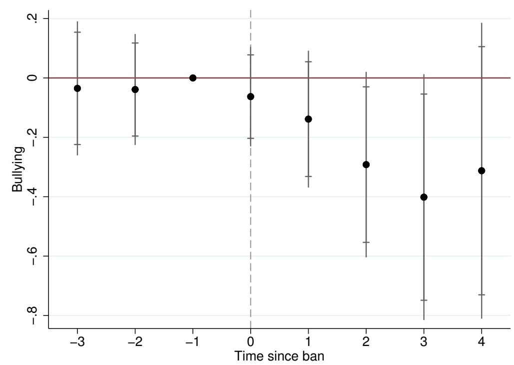
(d) P(Academic track=1) boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are mother's education, mother's age at the birth of the child, mother's marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates, and the individual's birth order. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

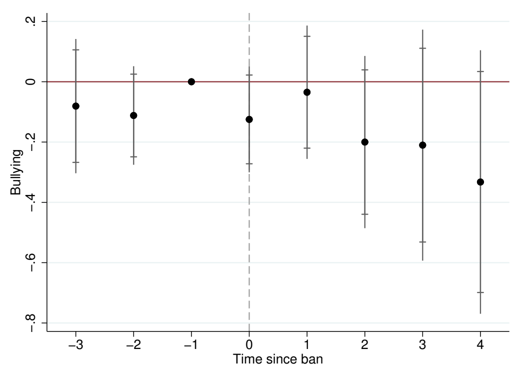
Figure 13: Bullying



(a) Bullying full sample



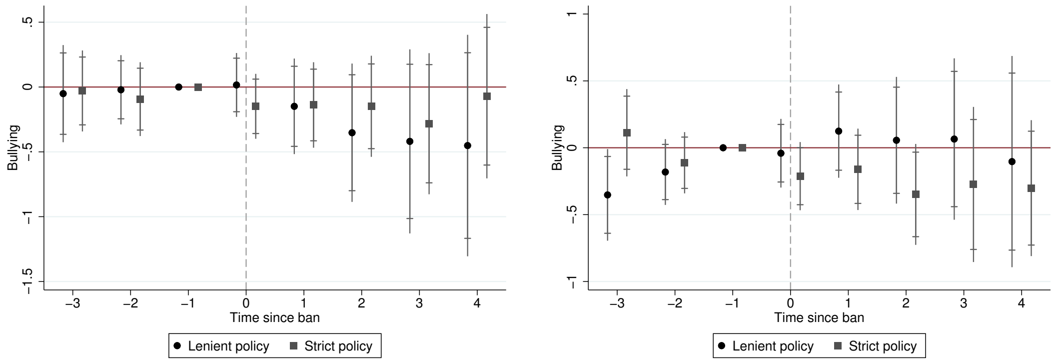
(b) Bullying girls



(c) Bullying boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

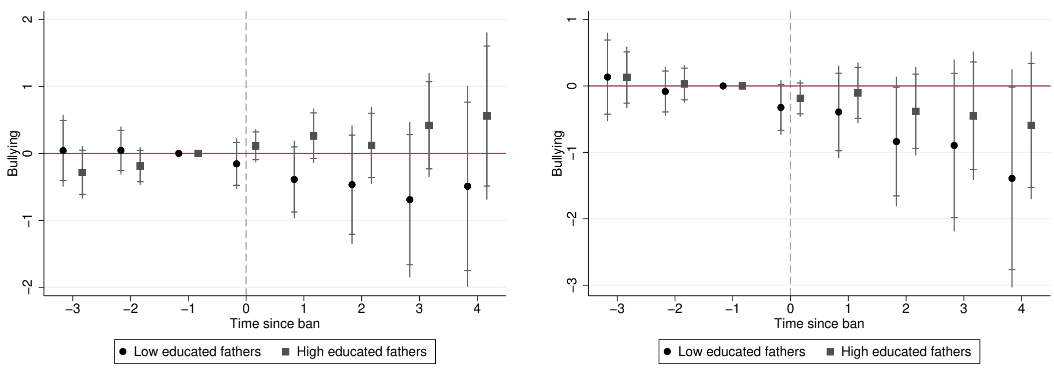
Figure 14: Bullying by type of ban



(a) Bullying girls (b) Bullying boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

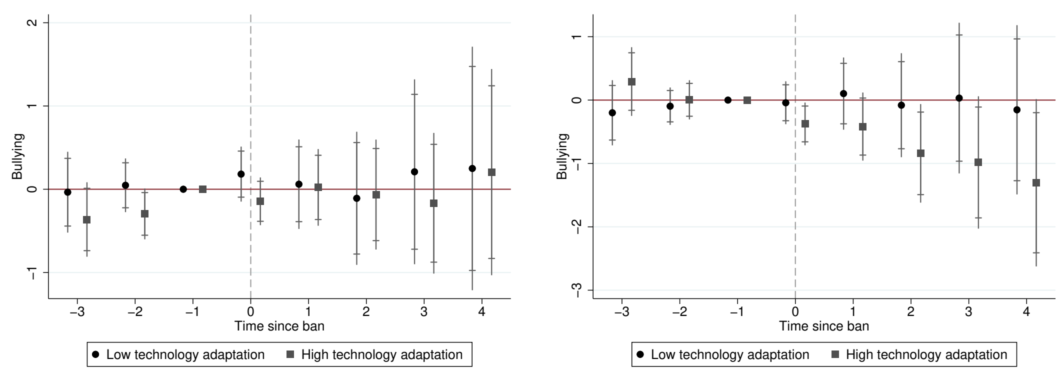
Figure 15: Bullying by father's type of high school education



(a) Bullying girls (b) Bullying boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 16: Bullying by low- and high-tech schools



(a) Bullying girls (b) Bullying boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Table 5: Effects of smartphone ban on student performance using a two-way difference-in-difference specification

	Baseline		Linear pretreatment	
	GPA (i)	P(Academic track=1) (ii)	GPA (iii)	P(Academic track=1) (iv)
	Panel A: Full			
Up to 2 years before ban β_2	0.002	0.015**	0.018	0.010
	(0.011)	(0.008)	(0.013)	(0.008)
0–2 years after ban β_3	-0.006	0.016	-0.010	0.016*
	(0.010)	(0.009)	(0.011)	(0.010)
3 years or more after ban β_4	0.022	0.039*	0.034*	0.031
	(0.020)	(0.020)	(0.020)	(0.020)
Observations	151925	127955	151925	127955
	Panel A: Girls			
Up to 2 years before ban β_2	-0.005	0.008	0.014	-0.000
	(0.014)	(0.008)	(0.016)	(0.008)
0–2 years after ban β_3	-0.017	0.014*	-0.021	0.015*
	(0.013)	(0.008)	(0.013)	(0.008)
3 years or more after ban β_4	0.019	0.052***	0.034	0.041**
	(0.024)	(0.018)	(0.024)	(0.018)
Observations	75065	63094	75065	63094
	Panel C: Boys			
Up to 2 years before ban β_2	0.008	0.021**	0.020	0.019*
	(0.014)	(0.010)	(0.017)	(0.010)
0–2 years after ban β_3	0.006	0.017	0.003	0.017
	(0.014)	(0.012)	(0.014)	(0.012)
3 years or more after ban β_4	0.027	0.029	0.037	0.026
	(0.026)	(0.025)	(0.027)	(0.026)
Observations	76857	64856	76857	64856

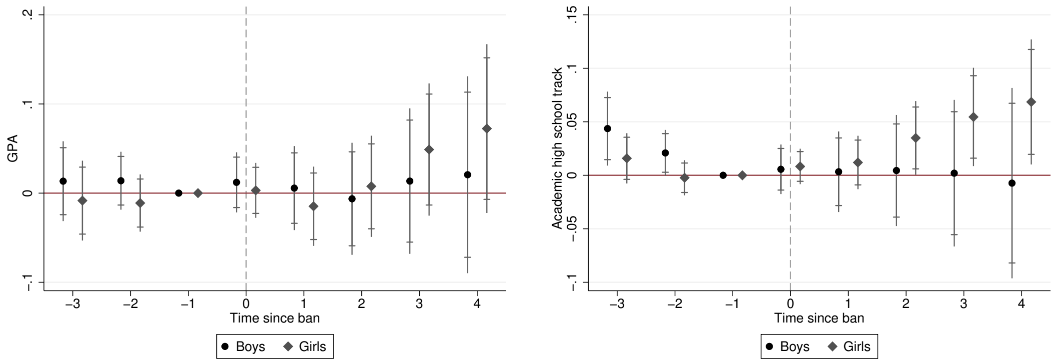
Notes: All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level and shown in parentheses. Additional control variables are the individual's test score in grade 5, mother's education, mother's age at the birth of the child, marital status at the birth of the child, father's education, father's age at birth, a dummy for having foreign-born parents, a dummy for being 1 year older than classmates, a dummy for being 1 year younger than classmates and the individual's birth order, peers test score in grade 5, and a dummy controlling for leadership change. Significance levels: *** 1% level, ** 5% level, * 10% level.

Table 6: Effects of smartphone ban on bullying using a two-way difference-in-difference specification

	Baseline	Linear pretreatment
	Bullying	Bullying
	(i)	(ii)
	Panel A: Full	
Up to 2 years before ban β_2	-0.126*	-0.079
	(0.073)	(0.084)
0–2 years after ban β_3	-0.090	-0.102
	(0.074)	(0.078)
3 years or more after ban β_4	-0.229*	-0.193
	(0.134)	(0.134)
Observations	2163	2163
	Panel A: Girls	
Up to 2 years before ban β_2	-0.090	-0.049
	(0.080)	(0.098)
0–2 years after ban β_3	-0.094	-0.104
	(0.075)	(0.078)
3 years or more after ban β_4	-0.247*	-0.216
	(0.141)	(0.142)
Observations	2024	2024
	Panel C: Boys	
Up to 2 years before ban β_2	-0.124	-0.104
	(0.080)	(0.089)
0–2 years after ban β_3	-0.074	-0.079
	(0.085)	(0.088)
3 years or more after ban β_4	-0.159	-0.144
	(0.156)	(0.155)
Observations	2037	2037

Notes: All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. Significance levels: *** 1% level, ** 5% level, * 10% level.

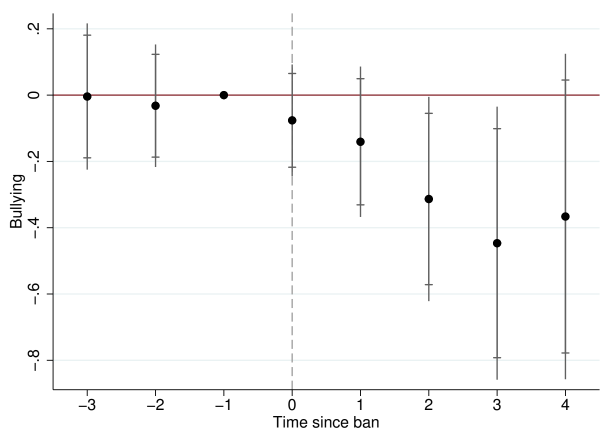
Figure 17: GPA and likelihood of attending an academic high school track by gender, excluding individual and parental control variables



(a) GPA by gender (b) P(Academic track=1) by gender

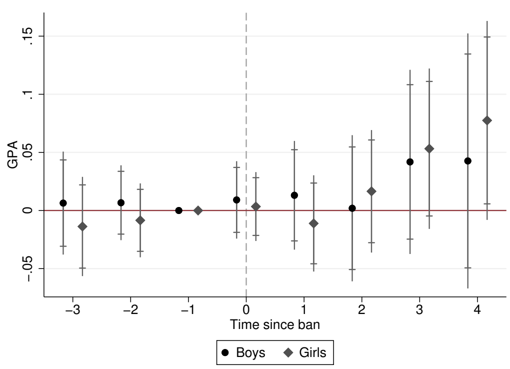
Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 18: Bullying girls, excluding control variables

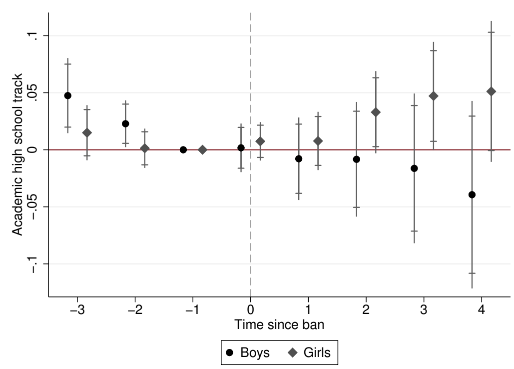


Source: The specification include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 19: GPA and likelihood of attending an academic high school track by gender, excluding the capital city Oslo



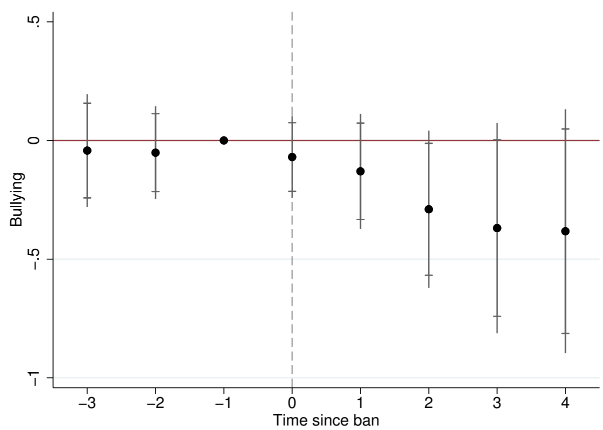
(a) GPA by gender



(b) P(Academic track=1) by gender

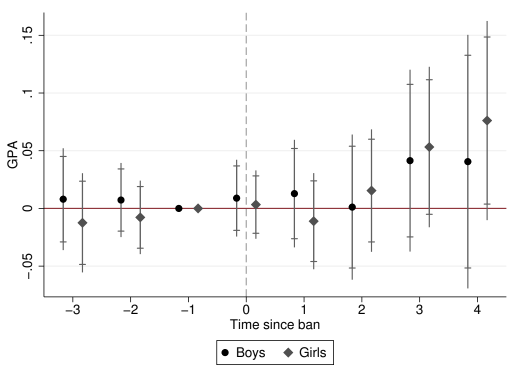
Note: Each graph is from a separate regression. All specification include a full set of cohort and school fixed effects. Robust standard errors are clustered at school level. Additional control variables are mother's education, mother's age at birth, marital status at birth, and father's education, father's age at birth, a dummy for having foreign born parents, a dummy for being one year older than classmates, a dummy for weather being one year younger than classmates and the individual's birth order. The reference year is one year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 20: Bullying girls, excluding the capital city Oslo

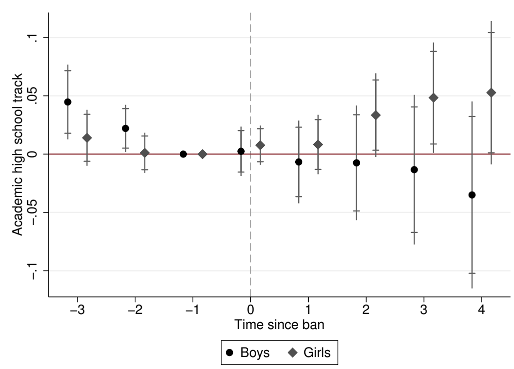


Source: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 21: GPA and likelihood of attending an academic high school track by gender, including the unemployment level at the municipality level



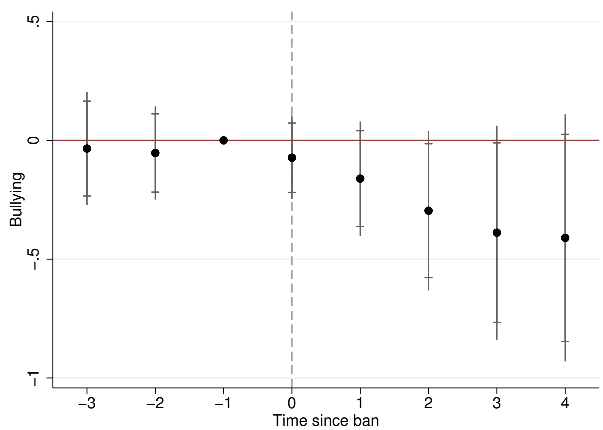
(a) GPA by gender



(b) P(Academic track=1) by gender

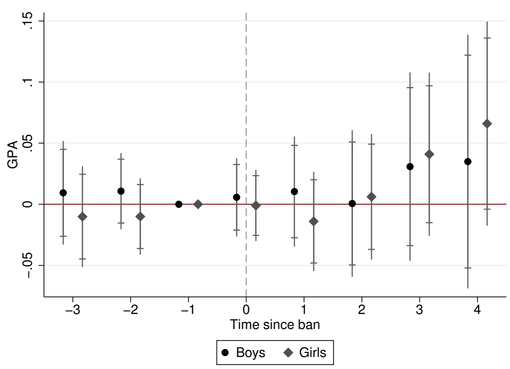
Note: Each graph is from a separate regression. All specification include a full set of cohort and school fixed effects. Robust standard errors are clustered at school level. Additional control variables are mother's education, mother's age at birth, marital status at birth, and father's education, father's age at birth, a dummy for having foreign born parents, a dummy for being one year older than classmates, a dummy for weather being one year younger than classmates, and the individual's birth order. The reference year is one year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 22: Bullying girls, including the unemployment level at the municipality level

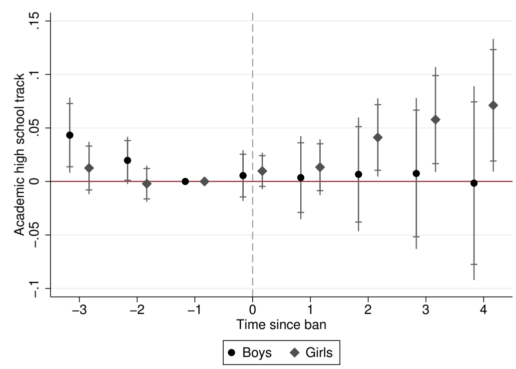


Source: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 23: GPA and likelihood of attending an academic high school track by gender, excluding private schools



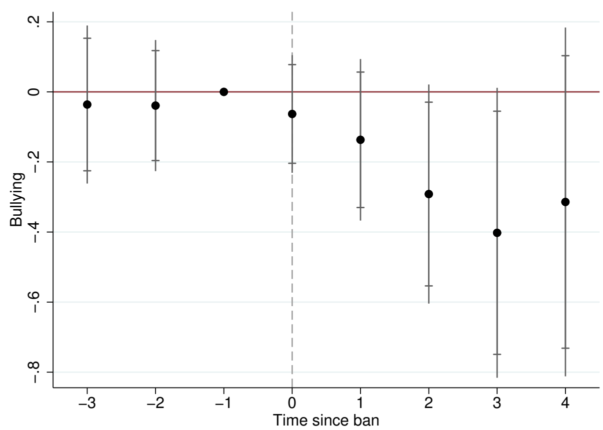
(a) GPA by gender



(b) P(Academic track=1) by gender

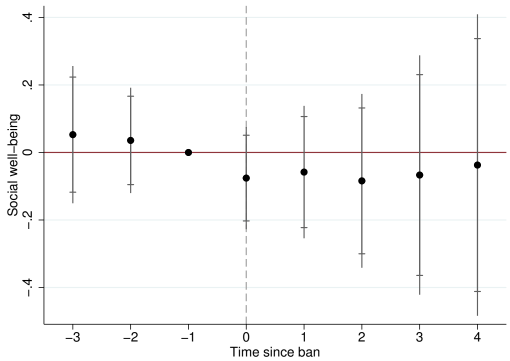
Note: Each graph is from a separate regression. All specification include a full set of cohort and school fixed effects. Robust standard errors are clustered at school level. Additional control variables are mother's education, mother's age at birth, marital status at birth, and father's education, father's age at birth, a dummy for having foreign born parents, a dummy for being one year older than classmates, a dummy for weather being one year younger than classmates and the individual's birth order. The reference year is one year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

Figure 24: Bullying girls, excluding private schools

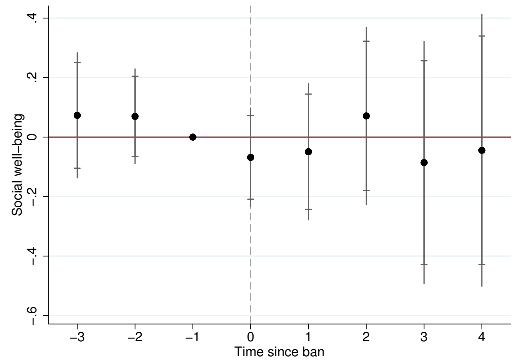


Source: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, and a dummy controlling for leadership change. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

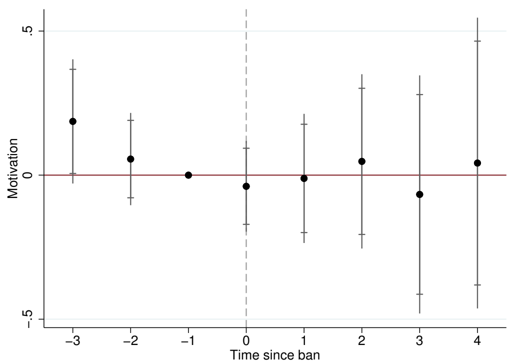
Figure 25: Social well-being, motivation, and pupil democracy



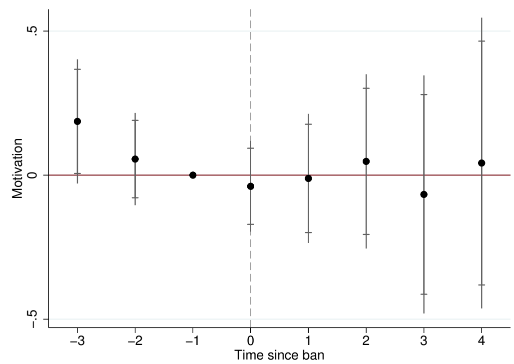
(a) Social well-being girls



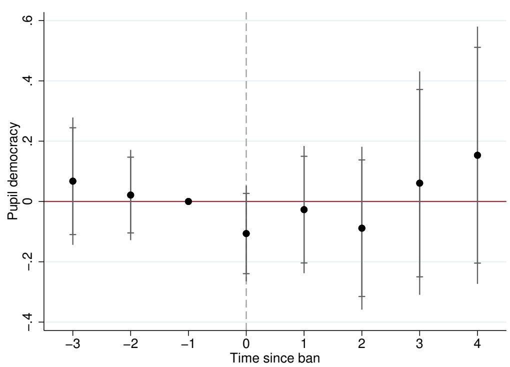
(b) Social well-being boys



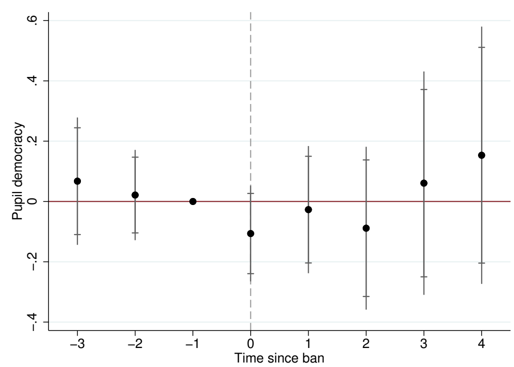
(c) Motivation girls



(d) Motivation boys



(e) Pupil democracy girls



(f) Pupil democracy boys

Note: Each graph is from a separate regression. All specifications include a full set of cohort and school fixed effects. Robust standard errors are clustered at the school level. Additional control variables are the mean of mothers' education, the mean of mothers' age at the birth of the child, share of students with married parents at birth, the mean of fathers' education, the mean of fathers' age at birth, share of students being 1 year older than classmates, share of students being 1 year younger than classmates, mean of birth order, share of students with foreign-born parents, mean of students' test scores in grade 5, a dummy controlling for leadership change and the unemployment level at the municipality. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.

A Appendix

A.1 Survey questions

The survey was sent out by email. It was in Norwegian, although questions and answer categories are documented in English.

Survey

1. Which school are you answering on behalf of?
2. Which alternative best describes your school's mobile phone policy?
   (a) Mobile phones are not allowed on school premises
   (b) Mobile phones are allowed, but should always be turned off or kept in "mobile phone hotels"
   (c) Mobile phones are allowed, but should always be on silent mode and turned off during class
   (d) Mobile phones are allowed, but should always be on silent mode
   (e) Mobile phones are allowed, but should not disturb during class
   (f) No mobile phone policy
   (g) Other
3. If "other", what mobile phone policy do you have?
4. Which year was your present mobile phone policy introduced?
5. Did you have another mobile phone policy before your present policy?
6. If yes, which alternative best describes your previous mobile phone policy?
   (a) Mobile phones are not allowed on school premises
   (b) Mobile phones are allowed, but should always be turned off or kept in "mobile phone hotels"
   (c) Mobile phones are allowed, but should always be on silent mode and turned off during class
   (d) Mobile phones are allowed, but should always be on silent mode

(e) Mobile phones are allowed, but should not be disturbing during class

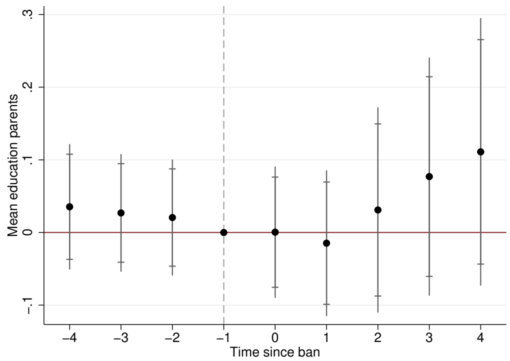
(f) No mobile phone policy

(g) Other

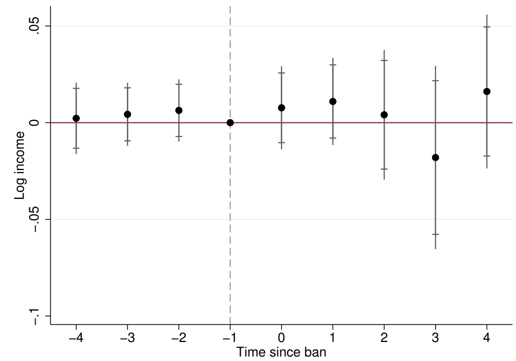
7. Do you have any other questions or comments?

A.2 Compositional effects

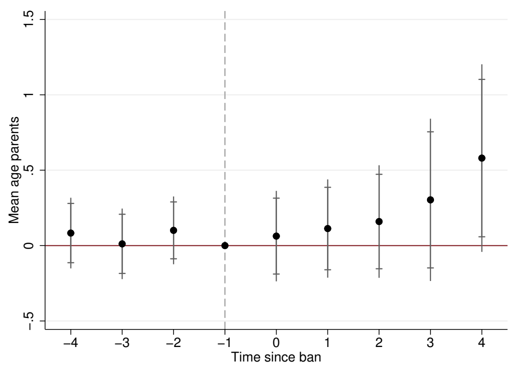
Figure 26: Event-study figures for compositional changes at the school level



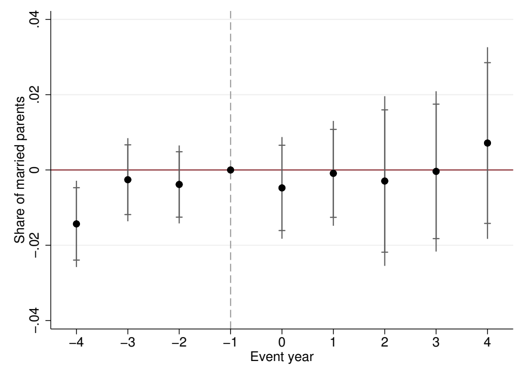
(a) Education of parents



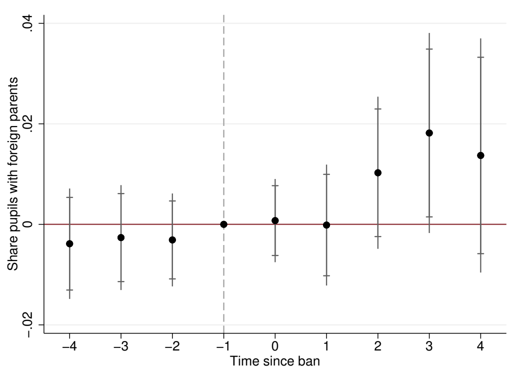
(b) Income parents



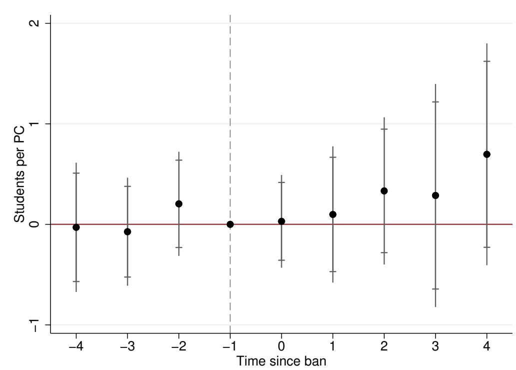
(c) Age of parents



(d) Share of students with married parents

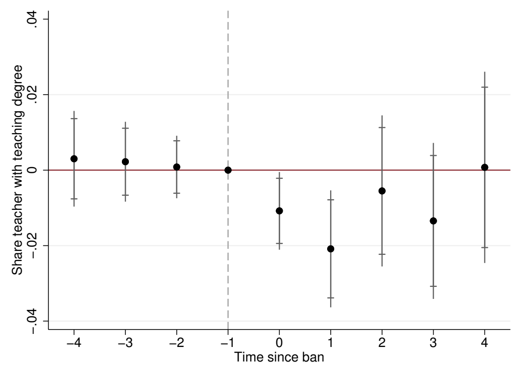


(e) Share of students with foreign parents

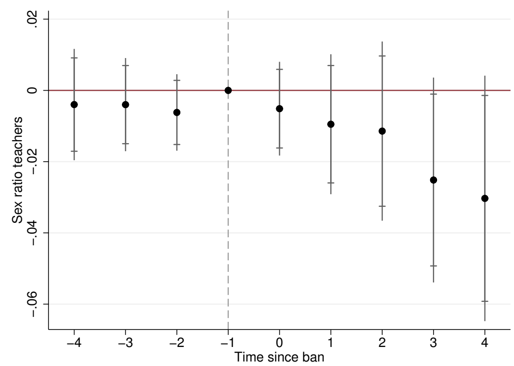


(f) Students per PC

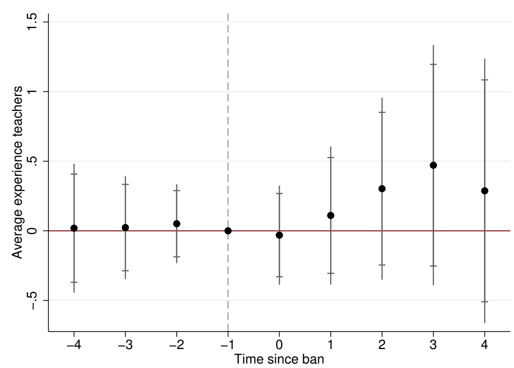
Figure 26: Event-study figures for compositional changes at the school level



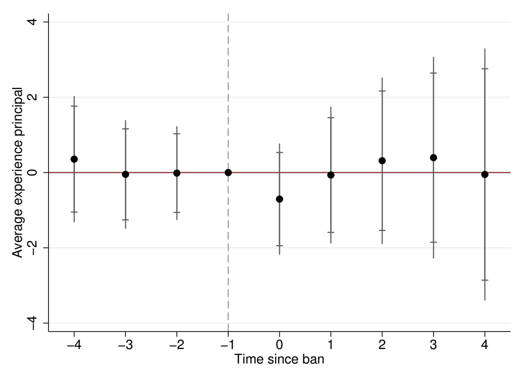
(g) Share of teachers with teaching degrees



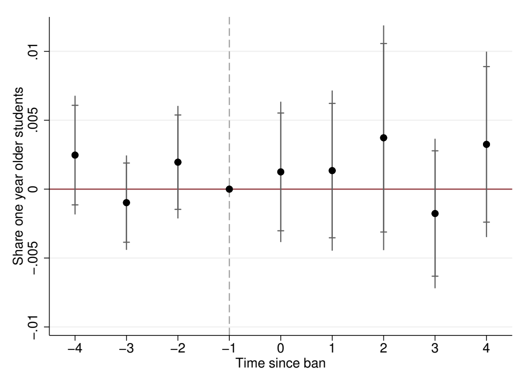
(h) Sex ratio teachers



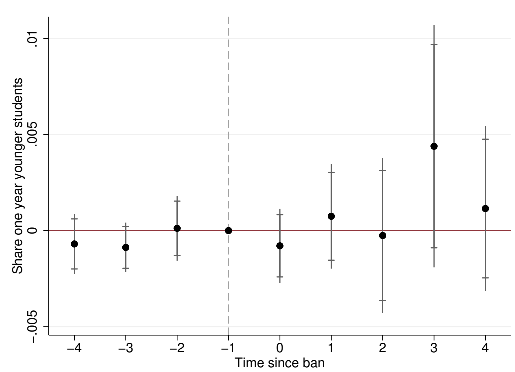
(i) Average experience of teachers



(j) Average experience of principal

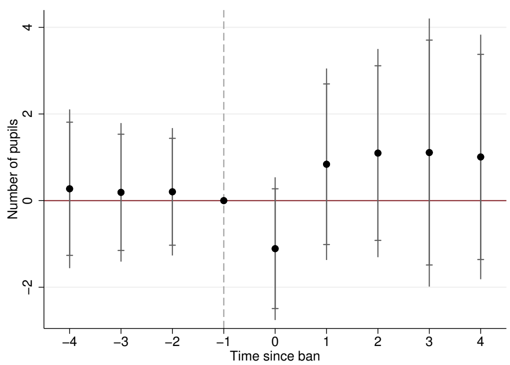


(k) Share of students 1 year older by cohort

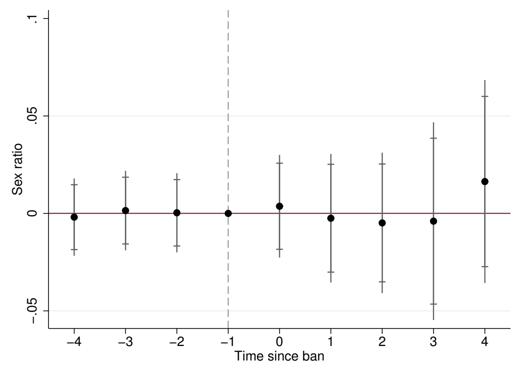


(l) Share of students 1 year younger by cohort

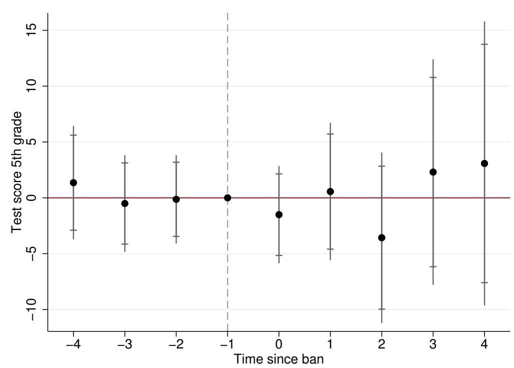
Figure 26: Event-study figures for compositional changes at the school level



(m) Number of pupils



(n) Sex ratio of pupils



(o) Previous achievement

Note: Estimated impact on various student, teacher, and socioeconomic characteristics of parents to students, conditional on school and year fixed effects. The reference year is 1 year prior to the introduction of a smartphone ban. Error bars show 95% and 90% confidence intervals.