NHH

Master Thesis, Department of Economics

Smarter Without Smartphones?

Effects of Mobile Phone Bans in Schools on Academic Performance, Well-Being, and Bullying

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Abstract

Smartphones have become a crucial part of the everyday life of Norwegian children, at school as well as in their spare time. What effect this presence has, is widely debated. As a reaction to this debate, Norwegian schools have implemented a broad variety of mobile phone policies. In this thesis, we are interested in how banning mobile phones on school grounds affects exam results, well-being, and bullying. To answer this, we link survey data from Norwegian lower secondary schools with their respective results on final written exams and the Pupil Survey. We use a generalized differences-in-differences framework and an event study specification to exploit the rollout of mobile phone bans. This enables us to identify a causal effect of a mobile phone ban on student outcomes.

The findings of this thesis indicate no significant effect of implementation of a mobile phone ban on academic results or well-being. When dividing the sample into public and private schools, we do, however, find that private schools experience a somewhat positive effect of a mobile phone ban on academic performance. Our estimates suggest that a ban causes reduced bullying. This effect is particularly strong for male students and in private schools.

This thesis has implications for schools considering implementing a mobile phone ban. If the motivation is increasing test results or well-being, other measures could be examined first. A mobile phone ban could, however, be considered if a school seeks to reduce bullying.

Acknowledgements

When discussing topics for our thesis, our starting point was that we wanted to write about a policy change. We wanted to devote this semester to investigate whether a certain policy has had the anticipated effects. We strongly feel that our chosen topic fulfilled this ambition. It has been rewarding to do research on a subject that we ourselves and people around us easily relate to.

We would like to thank our supervisor Aline Bütikofer for useful advice and feedback. Her guidance has been of great help, especially in moments of semi-panic. We would further like to thank Ranveig Kvinnsland and Margit Abel Grape for valuable input and proofreading. Lastly, we thank Norwegian lower secondary schools for showing great engagement when being contacted by us, and The Norwegian Directorate for Education and Training for data and support.

We further thank the city of Bergen for always providing the best writing weather. The fall of 2018 has made it especially easy to stay inside. Lastly, we want to give a shout-out to every single source of coffee at NHH and Circle K.

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1 Introduction

1.1 Motivation

Our society changes as technology infiltrates all parts of life. As humans are finding new ways to use technology for good, more people also advocate life without depending on devices and gadgets. New technology attracts both apostles and prophets of doom, who engage in one of our time's most prominent discussions. How are mobile phones changing our way of life?

There are some obvious advantages of increasingly smarter mobile phones. We are able to communicate with each other instantly, share our location, monitor our health and exercise, and learn about new subjects in new ways. We are living our lives differently than we were just ten years ago, connected and available at all times. Being able to daily keep in touch with peers online is also found to promote a sense of belonging and self-disclosure, which are important factors in identity development during adolescence (Davis, 2012). While these advantages for many outweigh the disadvantages, more research on problematic aspects of smartphone use has come forward in the last years (Elhai, Dvorak, Levine, & Hall, 2017). Research on the way smartphones are affecting the generation growing up today is often alarming. One study warns that children who spend substantial time on smartphones and screens, and less time on non-screen activities, exhibited lower psychological well-being (Twenge, Martin, & Campbell, 2018). This included reported measures such as self-esteem, happiness, and life-satisfaction. A second study found that adolescents who spent more time on screen activity were more likely to report mental health issues such as depression (Twenge, Joiner, Rogers, & Martin, 2017). This new perspective has led policymakers to debate what responsibility they have in sheltering the younger generations from potentially negative effects of smartphones.

On July 30, 2018, French lawmakers agreed to ban all mobile phones on school premises for children up to 15 years old (Aftenposten, 2018). The national mobile phone ban sparked a worldwide debate that also reached Norway (Dagbladet, 2018; VG, 2018b; Minerva, 2018). An article from 2018 in the Norwegian newspaper Klassekampen stated that 74 % of all Norwegians think Norway should introduce a national mobile phone ban in all schools. The Minister of Education, on the other hand, says each school should decide which rules suit them best (Klassekampen, 2018).

The effect of mobile phones on students' academic achievement and well-being is the core of the debate. While some are advocating the positive effects of technology in education, and mobile phones in particular, others warn against the potential dangers of distraction.

Which effect dominates is an empirical question. In their study, Beland & Murphy (2016) found a significantly positive effect of mobile phone bans on academic performance. This effect was mainly driven by low-achieving students. These students are also the ones reporting being most distracted by off-task activities during class (Krumsvik, Ludvigsen, & Urke, 2011). Beland & Murphy (2016) also found that the improvement of test results due to mobile phone bans was equivalent to adding one extra hour to each school week. This illustrates the potential resource perspective of mobile phone bans.

In this master thesis, we aim to measure whether there is a causal effect of a mobile phone ban on academic performance, well-being, and bullying. The academic results of school children are of great importance to policymakers, as these students ultimately define the future labor force. The students' well-being and experienced bullying are also key aspects in this regard. Bullying continues to be a prevalent problem in Norwegian schools, with more than 50 000 children being bullied more than three times per month (Wendelborg, Røe, Utvær, & Caspersen, 2017). Policy makers continuously try to reduce this number (Udir, 2017). Empirical research on the effect of a mobile phone ban on these outcomes can therefore be of importance, as it may be a cost-efficient measure to tackle important issues. We will exploit differences in the introduction of mobile phone bans in school and their strictness, to analyze how this affects student outcomes.

1.2 Research Question

Based on this motivation, our research question is thus:

How has the introduction of mobile phone bans in Norwegian lower secondary schools affected academic performance, well-being, and bullying?

We will answer this question in the following chapters. Chapter 2 describes the Norwegian educational system and the use of technology, exams, and surveys. Chapter 3 is a literature review where we examine the relevant literature for our thesis. In Chapter 4, we describe the data set we use as a basis for our analysis, and in Chapter 5 we explain our empirical model. We present our results in Chapter 6 and conduct robustness analyses in Chapter 7. We discuss potential weaknesses in our thesis in Chapter 8. We conclude our thesis in Chapter 9.

2 Background

In this chapter, we first describe the Norwegian school system and how it implements technology. Second, we discuss mobile phone policies in Norwegian schools. Further, we describe the grading system for insight into how Norwegian students are assessed. We then describe the Pupil Survey, which maps the students' self-reported well-being and bullying. The private school system in Norway is described at the end of the chapter.

2.1 The School System in Norway and Use of Technology

Norway introduced universal schooling more than 250 years ago. Since then, the school system has changed a number of times. The version we know today was introduced in 1997 and was a part of a larger reform (The Norwegian Ministry of Education, 1996). Compulsory schooling now lasts for ten years, and children start school at the age of six (The Norwegian Ministry of Education, 2018). The first seven years is called primary school, while the latter three is called lower secondary school. The municipalities are responsible for primary and lower secondary schools. Within a given regulatory framework, the municipalities, schools, and teachers have the freedom to decide which learning methods are most appropriate for given situations in primary and lower secondary school (The Norwegian Ministry of Education, 2018).

When the Knowledge Promotion Reform was introduced in 2006, digital competencies was added as a basic knowledge each student should obtain (Udir, 2018b). This meant that in addition to possessing basic skills in reading and mathematics, students should also through their education learn to collect and use information, be creative with digital tools, and communicate with others through digital resources (Udir, 2018b).

According to the Education Act, every school has to provide technological tools in order to teach the students required digital competencies (Udir, 2018d). The tools include personal computers, as well as mobile technology such as tablets (Aftenposten, 2016). It is up to each individual school and teacher to decide whether mobile phones can be used for educational purposes (VG, 2018a).

2.2 Mobile Phone Policies in Norwegian Schools

95% of Norwegian children between nine and eighteen have their own smartphone (Medietilsynet, 2018). From 2014 to 2018, the share of children between nine and eleven owning

smartphones increased from 67% to 87%. This share is even higher for children between 12 and 14, increasing from 90 to 97%. 89% of children spend time on their phone and 49% use two hours or more daily. Girls generally use their phone more than boys, especially for social media (Medietilsynet, 2018).

There is no national mobile phone policy in Norwegian schools and each school decides its own policy through the individual school regulation (Barneombudet, 2018). The Education Act regulates how strict the schools are able to be. Teachers are able to withdraw mobile phones if they are disturbing the class, but the phones must be given back to the students at the end of the day (Udir, 2018c). Schools are not allowed to keep phones overnight, as the school regulations cannot apply to the students' free time. The municipalities can choose to have common regulations for all schools in the same municipality (Udir, 2018c).

Norwegian schools have chosen many different variations of mobile phone policies (Dagsavisen, 2018). While some schools advocate the use of mobile phones for educational purposes, others have completely banned them from school grounds (Dagsavisen, 2018). There are many variations in between, for example that students are allowed to use their phones during recess, but otherwise keep them out of sight (Barnevakten.no, 2017).

As a part of this thesis, we have sent out a questionnaire asking all lower secondary schools in Norway about their mobile phone policy. The amount of answers we received indicates that this debate engages broadly in the education sector.[1] The principals we surveyed used the "other comments" section actively, further suggesting the relevance of this topic.

The schools answering the survey have demonstrated the wide array of opinions in this debate. From one school to another, the perspective on mobile phones can be completely opposite. Where one school mention that their mobile phone ban stems from a wish from the students, others report of great opposition from the students when trying to implement a ban. In other cases, a mobile phone ban is either initiated or stopped by parents who have strong opinions about their children's mobile phone usage while at school. Some schools advocate the use of mobile phones during class for educational purposes, stating that doing otherwise would be to deprive their students of valuable tools for better learning. Schools specifically commenting this are, however, a minority in our survey. The majority that have commented have had positive experiences with mobile phone bans and many also state that more schools should follow their lead.

[1] We sent the questionnaire to principals at Norway's 1250 lower secondary schools. We received a total of 605 answers from the beginning of September to mid-October.

There is little focus on the effect of a mobile phone ban on academic achievement in the comment section. The schools advocating a ban focus mainly on the social effects, explaining that their students are more present and communicate better with each other when they do not have access to their phones.

2.3 The Grading System

Norwegian students are graded for the first time when they start lower secondary school at the age of 12 or 13. They are assessed regularly and at the end of each semester (Udir, 2016). The final grade they receive, which in some cases will define which upper secondary school they go to, is decided in the final semester of the third year. This grade is called the overall assessment grade and should be set on a basis of all previous work and development during the three years at lower secondary school (Udir, 2018a).

In addition to the overall assessment grade in each subject, every student at lower secondary school also has one oral and one written exam at the end of 10^{th} grade (Udir, 2018f). The written exam is centrally administered and aims to test the students in the curriculum in each respective subject. The written exam is either in Norwegian, English or mathematics and is conducted by The Norwegian Directorate for Education and Training, further called Udir. The municipalities are responsible for making sure that the share of students having each subject is balanced every year. The oral exam is locally given at each school (Udir, 2018f).

2.4 The Pupil Survey

According to the Education Act, all students have the right to *a good physical and psychosocial learning environment that promotes health, well-being and learning* (Opplæringslova, 2016). As a part of the work to achieve this, the schools, municipalities, and the state conduct the Pupil Survey (Wendelborg et al., 2017) every year. The survey is mandatory for 10^{th} grade, and these results are published by Udir. Udir is responsible for conducting the survey (Wendelborg et al., 2017).

In the survey, students answer questions about well-being, motivation, whether they are bullied, whether they feel that they are being academically challenged, and their sense of mastery in school. The responses to this survey are supposed to help schools, municipalities, and the state to improve conditions for students.

2.5 Privately Owned Schools in Norway

The Private Education Act states that parents should be able to choose schools for their children that are not a part of the public school system (Friskolelova, 2018). The Ministry of Education can agree to the creation of a privately owned school on a basis of for example religion, pedagogical method, or international orientation. The creation of schools that will undermine the public school system will not be approved by the Ministry of Education. According to Statistics Norway, 3.8% of the total student mass in primary and lower secondary schools went to private schools in 2017 (Norway, 2017).

3 Literature

In this chapter, we present the most relevant literature and conclude what implications this literature has for our thesis. We start by presenting findings on the effects of computers in school, before we continue with the effect of mobile phones in school. Lastly, we present literature on the effect of mobile phone bans on academic performance. The most relevant existing literature for our thesis is a study on mobile phone bans at English schools (Beland & Murphy, 2016). To our knowledge, there has been no quantitative study of the effects of mobile phone bans on academic results, well-being, or bullying in Norway.

3.1 Technology in Schools and Distraction

The implementation and use of computers in schools is fairly new, and research has yet to agree on clear positive or negative effects of technology on student outcomes (Beland & Murphy, 2016). Laptops have become increasingly common in classroom settings (Weaver & Nilson, 2005). In Norway, this happened particularly after the government introduced digital competencies as a fifth basic competence (Krumsvik et al., 2011). The introduction of laptops in education has led to a variety of studies examining the effect of this tool on student learning. Some researchers advocate a positive learning effect of computers in classrooms (Brown & Petitto, 2003; MacKinnon & Vibert, 2002; Siegle & Foster, 2001). A common denominator is that the effect is due to integrated use of subject-related digital tools or software. Barrera-Osorio & Linden (2009) examined the effects of the *Computers for Education* program in Colombia using a sample of 97 schools in a two-year randomized evaluation. They exploit the fact that the computers were randomly distributed to get a causal effect. They conclude that the implementation of computers in education had none or little effect on student outcomes. The authors find the teachers' lack of integration of computers into the curriculum as the most likely reason for their results. This is consistent with the aforementioned papers.

A large variety of studies find computers to be a source of distraction and thereby providing a negative effect on student learning. In their research, Kraushaar & Novak (2010) installed monitoring software on students' computers, and categorized different mediums into productive and distracting. They then examined whether distracting multitasking during class had any effect on academic performance. They found that instant messaging during class had a significant and substantially negative correlation with learning outcomes, even though this activity requires a short time period of distraction. Other laptop activities such as surfing, entertainment and emailing did not have any negative effects on academic performance (Kraushaar & Novak, 2010). The effects they

find are, however, not causal findings.

In their study, Malamud & Pop-Eleches (2011) use a regression discontinuity design to get at a causal effect of home computers on children's outcomes. They exploit a voucher program in Romania, allocating funding for computers for low-income children. They find that children who received a voucher got significantly lower academic results.

Krumsvik et al. (2011) conducted a mixed method study where they used both qualitative and quantitative methods to evaluate technology in Norwegian high schools, from the perspective of both teachers and students. In this study, only 3% of the students report they have never used non-relevant computer activities while at school, while 28% report they use it often.[2] When asked what they mainly do on their computer, over 70% say they visit Facebook. 24% of the students unsolicited mentioned Facebook, most of them as a temptation and an obstacle for learning. As 41% of Norwegians say they use Facebook because of Messenger (Sandvik, 2018), this result would be consistent with the Kraushaar & Novak (2010) study claiming that instant messaging is the most distracting activity. The students also report that they perceive themselves as poor at multitasking. Only 9% of students asked in the study report that they completely agree that they can multitask. Boys reportedly spent more time on non-relevant computer activities at school than girls.

3.2 Effect of Mobile Phones on Concentration

The use of mobile technology for educational purposes has increased, and according to Ozdamli (2012), "cost, adaptability, and scalability are among motivations most often cited for using mobile technologies in learning". As mobile technology such as tablets has become increasingly popular, Haßler, Major, & Hennessy (2015) found that a majority of studies concluded that the use of tablets has had positive effects on learning outcomes. We have, however, not been able to identify research comparing the use of tablets with mobile phones in educational settings. This field of research could potentially be relevant for identifying distracting effects caused by the fact that students bring their own device with their own applications when mobile phones are used.

There exists some research on the use of mobile phones in education. When not integrated fully into education, the use of mobile phones during class can have negative effects (Kuznekoff & Titsworth, 2013). In a field experiment, Kuznekoff & Titsworth (2013) found that students who were not using their phones when watching a video wrote down

[2]Non-relevant computer activities are defined as activities that are not subject-related or related to the topic of the class in any way.

62% more information. They also found that these students earned a full letter grade and a half better on a multiple choice test after the video than the students using their mobile phones actively. Mendoza, Pody, Lee, Kim, & McDonough (2018) performed similar experiments, dividing participants into two groups that got to keep or had to remove their mobile phone during a lecture. The students who kept their phones received distracting text messages as a part of the experiment, and all students had to take a test after the lecture. The researchers found that participants who kept their phone performed worse on the test, indicating the potential distracting effects of phones in education.

Multiple studies also cite that the use of social media and smartphones is negative for adolescents' psychological health and well-being (Twenge et al., 2018; Twenge et al., 2017; Shakya & Christakis, 2017; Elhai et al., 2017). Difficulty concentrating and other cognitive problems are again directly linked to mental health (Association, 2013). In a Norwegian qualitative study, the reduction of cyberbullying is mentioned as the main motivation for many schools who have banned mobile phones (Fritze, Haugsbakk, & Nordkvelle, 2017). The authors of this study find that bullying can be reduced when introducing a mobile phone ban. They further emphasize the importance of class management when trying to reduce the negative effects of mobile phones in school (Fritze et al., 2017).

3.3 Research on Mobile Phone Bans

Beland & Murphy (2016) investigate the link between mobile phone bans and academic performance. They survey 90 schools in four larger cities in England about their mobile phone policies and link this data with administrative data on test results. Using a differences-in-differences framework, they find that a mobile phone ban had a positive and significant effect on test scores. Their empirical framework allows this effect to be interpreted as a causal effect. Lower-achieving students benefited most from the ban, while the ban did not significantly affect higher-achieving students.

3.4 Implications for Our Thesis

Based on the literature we have investigated in this chapter, there is limited evidence of technology having positive effects on academic performance. There is some evidence of it having negative effects, both on academic results, as well as well-being and bullying. When incorporated properly into education, mobile technology such as tablets can have positive effects, while access to mobile phones can have negative effects. Students' lack of ability to concentrate when having access to their phone is striking and thoroughly

proven. This is also the case for the negative consequences of mobile phones on young people's mental health and well-being. Beland & Murphy's paper is especially relevant for our thesis as it directly and empirically addresses mobile phone bans.

4 Data

In this chapter, we present the data we use in our analysis. The goal of this thesis is to investigate the effect of a mobile phone ban on students' academic results, well-being, and bullying. To do this, we have constructed a data set containing information about Norwegian lower secondary schools' mobile phone policies, exam results and scores on the Pupil Survey. Relevant control variables are also included. The analysis period is ten years, from 2007 to 2017. Data on mobile phone policies were gathered by us through a survey, while data on exam results and the Pupil Survey are available from Udir.

We start by presenting the mobile phone policy survey. Further, we present data on academic results and the Pupil Survey, and the relevant rules for making this data public. We then present the relevant control variables, and lastly selected descriptive statistics of the final data set.

4.1 Survey on Mobile Phone Policies

As previously described, there is no national mobile phone policy in Norway. This implies that the municipalities, and in most cases the schools themselves, have full autonomy in deciding their own regulations. It does not exist any national record on either present or historical mobile phone policies for us to use. We therefore created an online survey and circulated it to all lower secondary schools in Norway to map their mobile phone policy history. Our goal was to make a short and concise survey that did not require much time or any subjective assessments of the respondent.

After contacting Udir, we received a complete list of lower secondary schools and relevant contact information. This list contained 1250 schools, their postal address, email address, municipality, as well as whether it was a lower secondary school, or combined primary- and lower secondary school.

We directed an email to every principal and circulated the survey on September 7, 2018. The email contained some basic information about our thesis, a link to the survey, information about privacy and our contact information. In the survey, principals were asked to define their current mobile phone policy. They were given six possible alternatives, from most strict to most lenient, in addition to the alternative "other".

We define the degrees of strictness as follows:

1. No mobile phone policy
2. Mobile phones are allowed, but should not be disturbing during class
3. Mobile phones are allowed, but should always be in silent mode
4. Mobile phones are allowed, but should always be in silent mode and turned off during class
5. Mobile phones are allowed, but should always be turned off or kept in "mobile phone hotels"
6. Mobile phones are not allowed on school premises

The principals were also asked whether they previously had a different mobile phone policy, and if so, what this policy was. The principals were able to leave other comments or questions at the end.[3]

From the September 7 to October 10, 2018, we received 605 answers. This is a response rate of 48.4%. Of these, 529 respondents had completed the survey. In some cases, the principal had no knowledge of the timing of the change of mobile policy.[4] In cases where schools have failed to answer all questions, or where they have answered two times with conflicting replies, we have contacted the school. In cases where a school had replied two times, and one answer was more complete than the other, we have used the most complete answer. After removing all observations where the timing of change of policy was unknown or happened gradually, our survey sample consisted of 493 complete answers.

We define a mobile phone ban as regulations that fully prevent the use of phones during the course of the school day. This implies that schools that either replied that mobile phones are prohibited on school premises, or that mobile phones should be turned off at all times or be in "mobile phone hotels", characterize as having mobile phone bans.

120 principals used the alternative "other" to describe their mobile phone policy. After reviewing these responds, we have classified them to fit with our scale of strictness. We found that a large majority of those answering "other" did in fact loosely match the alternatives presented in the survey. Many, for example, stated that mobile phones were collected at the beginning of the day and handed out at the end. We have identified this as having a mobile phone ban. Some have replied that mobile phones are prohibited, but that they can be used for educational purposes if the teacher finds this appropriate.

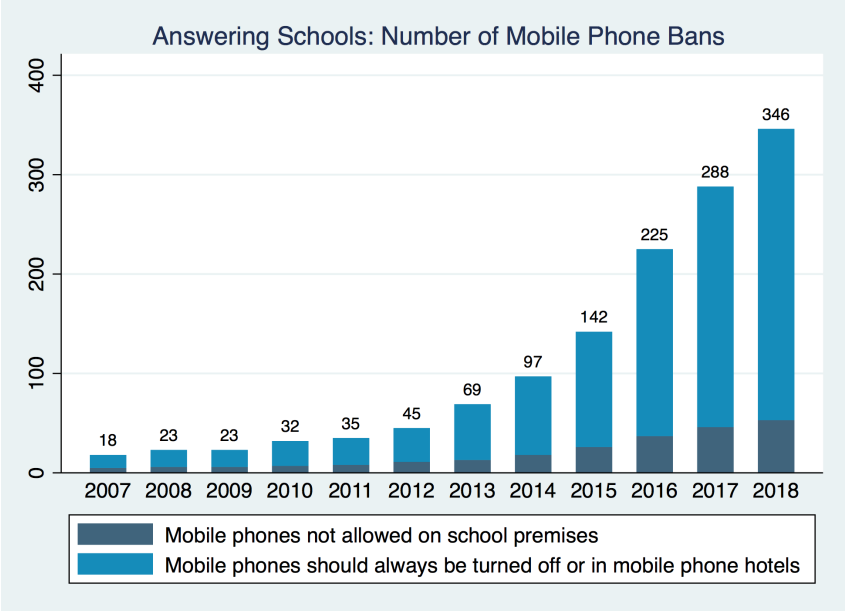
[3] See Appendix for all survey questions.

[4] 28 principals replied that they were unsure about when the current mobile phone policy was introduced.

These schools have been identified as not having a ban. If the students have access to mobile phones during class, it is difficult to ensure that mobile phones are solely used for educational purposes. In the survey data, the school year 2016/2017 is defined as 2016 and so on, unless otherwise specified by the school.

Figure 1 shows that the majority of the 493 schools in our survey sample now have what we define as a mobile phone ban. We see this policy gaining ground especially after 2014, and with increasing pace during the last few years. As mentioned in the introduction, the motivation
shows that the share of children owning smartphones has increased in this same time period. Although we cannot claim any causal connection between the two, it is possible that schools have seen the need to restrict the use of phones as a response to more distracting smartphones.

Figure 1: Number of Implemented Mobile Phone Bans Every Year



Notes: This figure shows the number implemented bans at all schools answering the survey.

Table A2 in the Appendix shows the mean degree of strictness on new mobile phone policies implemented every year. Before 2013, we see that few schools change their policy. The mean degree of strictness on new policies is thus based on a small number of schools, and should not be given too much weight. However, from 2013, we see a substantial amount of schools changing policies. The mean degree of strictness varies between 4.5 and 4.8 in recent years.

4.2 Exam Results

Udir publishes exam results for every school in any given year from 2007 to date. This data contains information on mean exam results (with one decimal) at each school in every subject, as well as information about school geography and gender. Only results from students who follow the ordinary educational pathway are included in the statistics. This means that students who receive special education or who are exempt from assessment do not affect the mean grade. Exams are graded on a scale from 1 to 6, where 1 expresses that the student has a very low competence in the subject, and 6 is given when the student has shown to have exceptionally high competence in the subject (Forskrift til opplæringslova, 2009).

The written exams are centrally administered and conducted at the same time for everyone drawn for the same subject. They are assessed by two external sensors, which makes for objective grading and ensures that results are comparable between schools. Oral exams are made by teachers at each respective school, and the assessment of each student is non-anonymous. This could potentially lead to results biased by the difficulty level of the exam set by the teacher, or the student's relation to the teacher. This makes the oral exams less objective than the written exams. We will thus use the written exam results as the main outcome for our analysis on academic performance. The subjects we will concentrate on are Norwegian,[5] mathematics, and English.

4.3 The Pupil Survey

Udir publishes the scores for the Pupil Survey every year, where the students reply to questions in a number of categories. We have chosen to include the average score on well-being and bullying in our data set. In each category, the schools can obtain a value on a scale from 1 to 5, where 5 is the highest possible average value. For well-being, the higher score, the more positive result. For bullying, schools would want a score as close to 1 as possible.

The Pupil Survey has been revised a number of times. From 2007 to 2012, the category "Well-being" was called "Social well-being", and included two more questions that after 2012 have been put into other subcategories of well-being. We still choose to include this category, as it is one of the broader categories that reflects how well the students like it at school. The bullying category has also changed its one question during the period of our

[5]Norway has two official written languages, Bokmål and Nynorsk. Every student defines which is his or her first- and second-choice form of Norwegian. In this thesis, we concentrate on the results in first-choice form of Norwegian, which we refer to as "Norwegian".

analysis. From 2007 to 2012, students were asked whether they had been bullied at school during the last few months. After 2012, the question changed to whether the student had been bullied by *other students* at school during the last few months. Several categories for bullying were introduced after 2012. We have used the category that still uses the 1 to 5 scale, "Bullying by other students at school", that is comparable to the one from 2007 to 2012, "Bullying at school".

4.4 Exemption Rules

As Norway has a large amount of smaller schools with only one or few students in every grade, observations are exempt from the public whenever it is possible to identify which student has taken a given test (Udir, 2018e). Udir has strict rules for when to leave out observations. If the school size is smaller than 30, the observations are missing for everyone. If all students are at the same level, observations on all levels are left out. If one of these rules apply for only one gender, both genders are missing. Further, if the mean result is based on the tests of one to nine students, the observations are missing, also if it applies for only one gender. If the schools fail to report the grades for less than 75% of their students, the mean grade will be missing.

The Pupil Survey is also covered by the exemption regulations. If a question is answered by ten students or less, the answers will be missing. This also applies for when there are too few students in either the male or female sample. If the response rate is less than 50% for the entire class, the result will be missing.

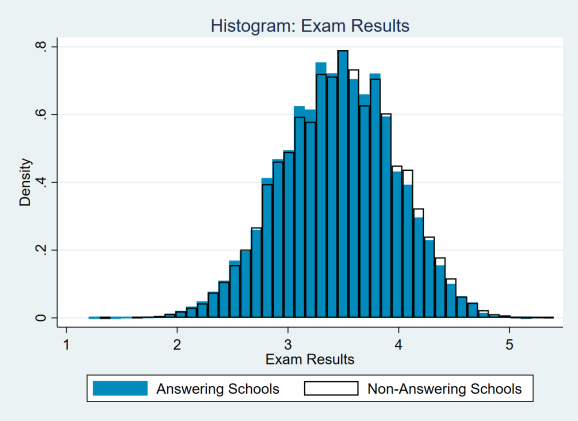
4.5 Control Variables

In addition to data about results, well-being, bullying, and mobile phone policies, we have included relevant control variables that may affect the outcomes we are interested in. When using exam results as an outcome variable, subject controls are included. This is in order to control for the fact that the subjects differ in results, as seen in Table A3. We consistently use Norwegian as a base subject, and control for whether the exam is in mathematics or English. Further, we control for school size by including the number of students at the school each year. We have also included data from Udir on student-teacher ratio, as this potentially can affect all outcome variables. A list of the control variables can be found in Table A1 in the Appendix.

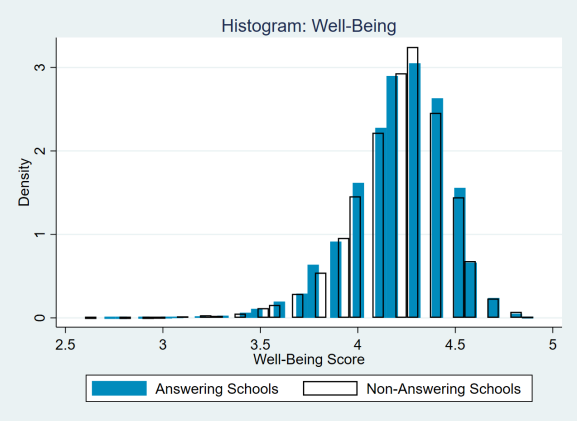
4.6 Final Data Set

When we combine the survey data with data on exam results and the Pupil Survey, additional schools have to be left out of the analysis due to missing observations. This is caused by the aforementioned exemption rules. As the final sample is approximately 30% of the total number of lower secondary schools in Norway, we want to investigate whether the sample is representative. Figures 2a, 2b and 2c show the distribution of our outcome variables at schools who did and did not answer the survey we circulated. We see that the sample of schools that answered the survey is not dramatically different from the schools that did not.

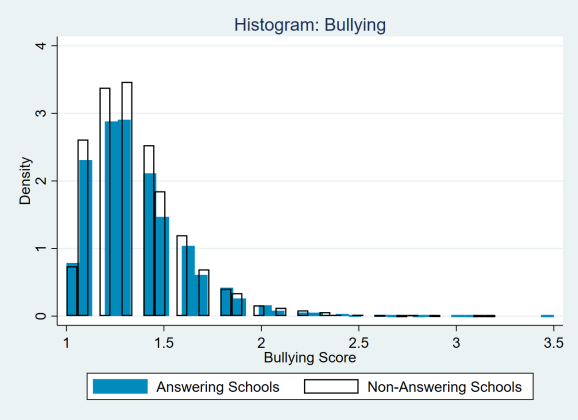
Figure 2: Various Outcomes: Answering and Non-Answering Schools



(a) Exam Results



(b) Well-Being



(c) Bullying

Notes: Non-answering schools are defined as those schools that are large enough to have public results and scores, but who have not answered the survey of mobile phone policy. The answering schools are defined as the schools who answered the mobile phone policy survey, and that also are large enough to have public records of exam results and scores on the Pupil Survey.

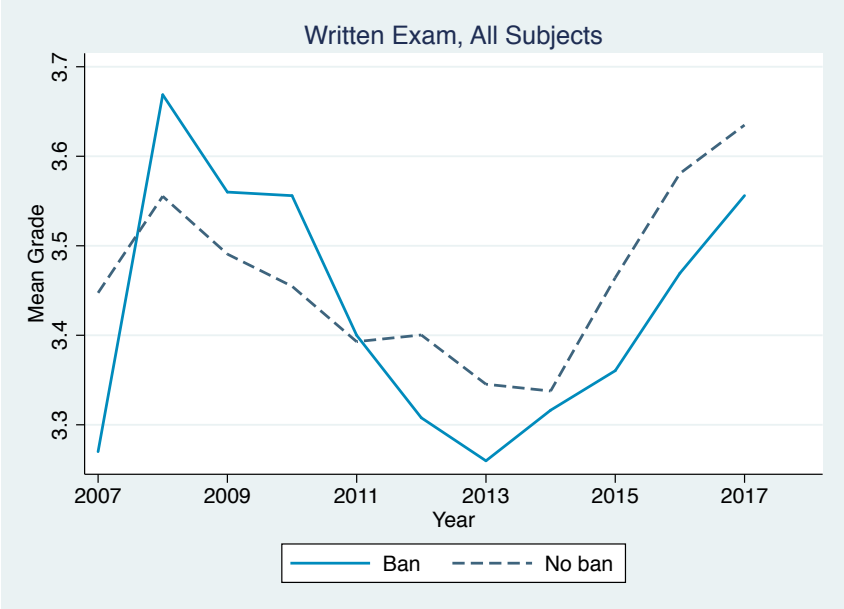
Mean grades in English, mathematics and Norwegian can be found in Table A3 in the Appendix. Female students perform consistently better than their male counterparts on

average, although the max score for males is slightly higher than for females in mathematics. The average score is highest in English, with 3.7 out of 6, and lowest in mathematics, with 3.2 out of 6. We see that the sample consists of slightly more observations on males than on females.

Table A4 in the Appendix presents some key numbers on well-being and bullying. On a scale from 1 to 5, the mean self-reported well-being is 4.22, and mean bullying is 1.34. Male students have a slightly higher score on well-being, but also report more bullying than the female students. The Pupil Survey also contains slightly more observations on males than females.

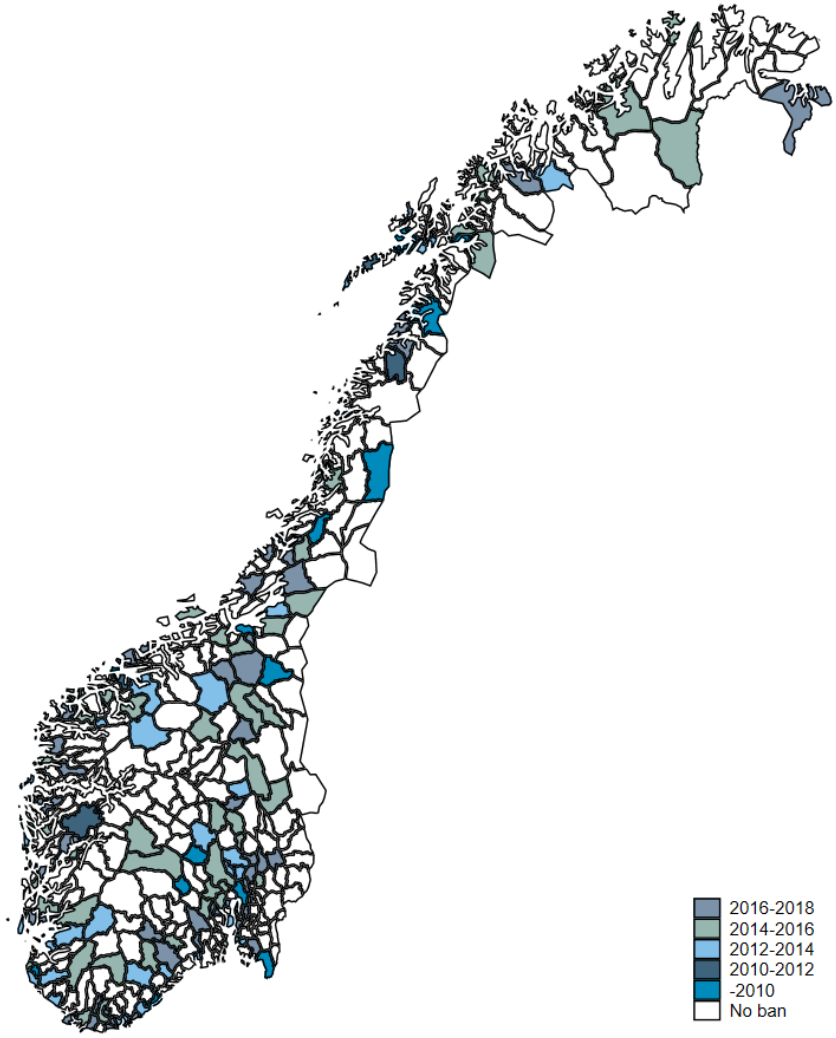
Figure 3 shows the development in mean grades at schools with and without mobile phone ban in every given year. We see an indication of ban schools and no ban schools being somewhat different in results. These potential differences will affect our analysis and are thus addressed further in Chapter 5 and 6.

Figure 3: Mean Grades at Schools With And Without Mobile Phone Bans



In Figure 4, we present a geographical spread of when mobile phone bans were first introduced in each municipality. Municipalities where no schools have mobile phone bans are marked in white. The year when the first school in the municipality introduced a ban will define the municipality's color on the map.

Figure 4: Implementation of Mobile Phone Ban in Each Municipality



Notes: The map shows the municipalities in Norway. Each color represents a time period of implementation of a mobile phone ban. The first school implementing a ban in each municipality will define the color.

5 Empirical Approach

Our main ambition with this thesis is to detect a causal effect of mobile phone bans on students' academic performance, well-being, and bullying in Norway. To do this, we have linked data on mobile phone policies together with results on final grade exams and average scores on bullying and well-being from the Pupil Survey. We identify the causal effect by investigating the rollout of mobile phone bans at different schools at different points in time, utilizing a generalized differences-in-differences approach. The key to our identification is that the schools have implemented their new policies in a quasi-random fashion. Our method relies on the premise that the change in mobile phone policy is independent of other changing variables affecting results, and therefore that the policy change affects the test results like an exogenous shock.

In this chapter, we present our empirical approach. We first present a generalized differences-in-differences method, with specifications. We further present an event study specification and discuss the assumptions that must hold for our method to be satisfactory.

5.1 Rollout

Our identification strategy is a generalized differences-in-differences setup. This method is used when treatment happens at different times for multiple groups or individuals. A condition for the differences-in-differences approach is to have a comparable treatment and control group, where the only factor dividing the two groups is the treatment (Angrist & Pischke, 2015). In our case, the treatment is introducing a mobile phone ban, and absence of treatment is not having a mobile phone ban. The treatment group is any school that has implemented a ban, and the control group is any school that at a given time have not implemented a ban, or never will. This implies that a particular school can be in the control group one year and in the treatment group the next.

This strategy has previously been exploited in papers such as Butikofer, Løken, & Salvanes (2015), and is thoroughly explained in Goodman-Bacon (2018). We estimate the following equation:

$$y_{imt} = \alpha + \gamma D_{it} + \pi X_{it} + \lambda_m + \theta_t + \varepsilon_{imt} \tag{1}$$

Where y_{imt} is our dependent variable, expressing outcome of interest at school i in municipality m at time t. The outcome variables are written exam results in 10^{th} grade,

self-reported well-being, and self-reported bullying. We use exam results at the final year of lower secondary school as the primary measure of academic achievement, because the share of students owning a phone is relatively large in this age group, as shown in Figure 8 in Appendix. D_{it} takes the value 1 if school i has implemented a mobile phone ban in time t, and γ is thus our key coefficient of interest, expressing the effect of a mobile phone ban on the outcome of interest. X_{imt} is a vector of school specific controls that are time variant, and π expresses the effect of these characteristics on our dependent variable.

We assume that there are unobservable components in the error term. To account for this, we control for fixed effects. λ_m is a set of municipality fixed effects, controlling for unobserved effects fixed at the municipality level, for example municipality size and geographical location. This variable will also control for differences between municipalities when it comes to whether lower secondary school grades are low stakes or high stakes, depending on whether the grades serve as a basis for upper secondary school admissions.[6] θ_t controls for unobserved year fixed effects, such as a difference in the difficulty of exams or other common time shocks.

5.1.1 Accounting for Privately Owned Schools

We have data on both public and private schools in our sample. Private schools experience higher mean grades than public schools but the score on well-being and bullying are relatively similar, see Table A5. We investigate whether the effect of introducing a ban is different depending on whether a school is private or public.

To do this, we add another interaction term to our empirical model, P_i, that takes the value 1 if school i is privately owned. We estimate the following specification:

$$y_{imt} = \alpha + \gamma D_{it} + \rho D_{it} P_i + \pi X_{it} + \lambda_m + \theta_t + \varepsilon_{imt} \tag{2}$$

where γ is still the coefficient of interest, as in Equation (1). We now identify another coefficient of interest, ρ, which measures the estimated effect of both having a mobile phone ban and being a private school.

[6] The results on 10^{th}-grade exams are high stake in many cases. Many Norwegian counties enable their students to apply to chosen upper secondary school using their lower secondary school grades (Vilbli.no, 2018). In counties where this is the case, the final exam results are high stakes, as they could determine which upper secondary school the student might get admitted to.

5.1.2 Accounting for School Size

In our baseline regression, every school is given equal weight. All schools are however not equal, particularly in size. We want our estimates to reflect this fact by weighting them dependent on their number of students. This might also increase the precision of our estimates. Large schools have a broader student mass and thus a smaller variance in student outcomes, while outcomes at small schools have larger variance. From a statistical view, large schools are therefore more reliable. This is another reason for weighting them more.

The method we use is called weighted least squares (WLS). A standard OLS estimator will minimize the sample average of square residuals and give each residual equal amount of weight (Angrist & Pischke, 2015). Using WLS, we weigh each term in the residual sum of squares by school size. According to Angrist & Pischke (2015), this method provides us with a student-weighted average, rather than an average over schools. We then get more weight on the causal effect of a ban from the large schools. As small schools might provide useful variation, we would want the weighted and unweighted effects to be similar. This would suggest that there is not much effect of heterogeneity in terms of school size.

5.2 Event Study

A good control group should reveal the state of the treatment group in a counterfactual world where it was not treated (Angrist & Pischke, 2015). In a difference-in-difference framework, pre-treatment trends are examined to argue for why the control group is suitable to predict the counterfactual outcome (Angrist & Pischke, 2015). In our case, this means examining the pre-existing trends in outcomes before schools implemented a mobile phone ban. If schools who implement a ban early turn out to mainly be on an upward sloping trend in student outcomes, while late introducing schools are on a downward sloping trend, this might hurt our analysis. The rollout would then yield a positive effect although the difference in school outcome is not necessarily affected by the ban.

We now solely focus on the schools that at some point introduce a ban. We test for the possibility that mobile phone bans are implemented if schools have particular trends in outcomes. To examine the pre-ban trends, we utilize an event study specification. This approach has been used in papers as (Bailey & Goodman-Bacon, 2015) and (Butikofer

et al., 2015). We estimate the following equation:

$$y_{imt} = \alpha + \sum_{\tau=-3}^{-2} \delta_\tau D_i 1(t - T_i^* = \tau) + \sum_{\tau=0}^{3} \sigma_\tau D_i 1(t - T_i^* = \tau) + \pi X_{it} + \lambda_m + \theta_t + \varepsilon_{imt} \quad (3)$$

Where y_{imt} is our outcome variable of interest. D_i is an indicator variable which takes the value 1 if school i ever implemented a mobile phone ban. $1(t - T_i^* = \tau)$ is the event-year dummy, which is equal to 1 when the year of observation is $\tau = -3, -2, 0, 1, 2, 3$ years from T_i^*, the year when a mobile phone ban was introduced. The estimates characterizing the anticipatory effect of a mobile phone ban is given by δ_τ, which measures the effect of the interaction term between D_i and the event-year dummies. σ_τ measures the effect of the mobile phone, relative to the last year before a ban was implemented. Year $t-1$ then serves as a control group. Observations more than three years before or three years after implementation of a ban are captured by dummies, so that $1(t - T_i^* =\leq -3)$ and $1(t - T_i^* =\geq 3)$. In addition to the event study specification, we include the same controls as in the rollout specification.

Significant values of δ_τ will indicate that the pre-trends could predict the outcome variable we measure. This would thus hurt the assumption that the rollout of bans is quasi-random. If δ_τ is insignificant, we find no evidence of particular pre-trends. If δ_τ is insignificant, and σ_τ is significant for all values of $\tau \geq 0$, then the coefficient σ_τ is the size of the causal effect in the years after implementation.

5.3 Validity of the Empirical Approach

Our empirical strategy relies upon the assumption that the rollout of mobile phone bans is quasi-random and uncorrelated with other determinants of test results. This means that no school characteristics should be predictive of when the school is implementing a mobile phone ban.

Figure 4 in Chapter 4 shows no apparent geographical pattern in the implementation of bans. We see that there were few municipalities that had schools with bans prior to 2012, and that these are spread around the country. The municipalities with schools implementing bans in recent years also seem to be as good as randomly distributed. Although this is no proof of random assignment in itself, it strengthens the argument that there is no particular geographical trend in the implementation of mobile phone bans.

There are however more aspects to consider when examining the conditional exogeneity assumption. Policy changes affecting the specific schools or municipalities could be a potential threat to identification if they are correlated with a change in mobile phone policy. Such policy changes could be relevant if they differ between the municipalities or schools, and thus are affecting the schools differently. The Knowledge Promotion Reform of 2006 introduced digital competency as a basic knowledge all students should obtain. It was, however, a national reform that affected all schools in our analysis. In addition, it happened before our data set begins, and should thus not affect our conclusions. Furthermore, changes in subject curricula could affect student outcomes, but these will also mainly happen on a national basis. Examples of relevant policy changes could be a change in leadership or leadership style at a school, new facilities, or new learning methods. Specific measures or efforts to reduce bullying could also be defined as such policy changes. These factors could potentially affect academic results, well-being, and bullying, which would make it more difficult to isolate the exact effect of a mobile phone ban. However, our survey does not provide enough detail about these factors, and Udir does not publish this information either.

5.4 Adjusting for Serial Correlation

As we have repeated values for each school in our data set, the panel structure of our data raises the problem of serial correlation (Angrist & Pischke, 2015). If we were to ignore this fact, our statistical conclusion could be misleading, and we could be exaggerating the precision of our regression estimates (Angrist & Pischke, 2015). We assume that there could be serial correlation within a school, meaning that the results at one school at different points in time are correlated. Because children within a school are exposed to the same environment and other background influences, we consider serial correlation to be likely. To account for this problem, we cluster the standard errors on a school level.

It could also be relevant to examine whether our estimated standard errors are sensitive to serial correlation on a municipality or county level. This problem could arise because municipalities have political control over their schools, or if there are geographical factors affecting results over the years. We account for this in the analysis.

5.5 Intention-to-Treat vs. Treatment-on-the-Treated Effects

When investigating a policy change, the true effect of the treatment depends on the nature of the policy. If everyone receiving treatment comply, the effect will be a treatment-on-

the-treated (TOT) effect. If the treated have the possibility of not complying, or the untreated have access to treatment, the effect will be an intention-to-treat (ITT) effect (Angrist & Pischke, 2015). As we only have access to school level data, not individual data, this will affect what kind of estimates we have. With the implementation of mobile phone bans, we are only able to observe the effect of the school having a mobile phone ban, not the actual effect of the ban on each individual student. We get the TOT effect on the schools, but not the treated student. With individual data, we would have had ITT estimates, as students could sneak in their phones, or other factors could hinder them from being treated with the mobile phone ban.

If we had known to what extent the ban was being complied with, we could have measured a more precise TOT effect. We did however not gather this information, as it would have required the school leaders answering our survey to show discretion when answering.

6 Main Findings

In this chapter, we present our empirical analysis. We divide the chapter into findings from the rollout specification and the event study specification. The rollout section is further divided into two analyses, where we examine both the effect of a ban in itself and the effect of the timing of a ban. This chapter will directly address our research question and presents the estimated effects of a mobile phone ban on exam results, self-reported well-being and bullying.

6.1 Findings Rollout

6.1.1 Full Sample

We begin by estimating the overall effect of a mobile phone ban on the full sample of schools in our data set. Table 1 presents the main estimated effect of a mobile phone ban on exam results, well-being, and bullying. These estimations are based on our first rollout specification given in Equation (1) in Chapter 5. In column (1), we present the total estimated effect of a ban. Column (2) shows the estimated effect on a ban on male students, while column (3) shows the estimated effect on female students. The regressions that form the basis for Table 1 control for gender, subject, school size, student-teacher ratio, as well as year fixed effects and municipality fixed effects. The outcome variable exam results refers to results in Norwegian.

We look at the outcome variables separately for the two genders in the main analysis. The reason for this is that there are certain gender differences in results, well-being, and bullying, as seen in Table A3 and Table A4 in the Appendix. Medietilsynet further reports that males and females use their phones in different ways and for different amounts of time. Lastly, schools might need to account for whether a phone ban affects the two genders differently when considering introducing one.

In column (1), we see that the estimated total effect of a mobile phone ban on exam results is close to zero and insignificant. When looking at males and females separately, we find that male students have a somewhat positive effect of a ban, while female students have a negative effect. This could potentially be because boys and girls use their phones differently, as discussed in Chapter 2. The effects are however not significant and the standard errors are large, indicating that these effects are ambiguous. We cannot conclude that the effect of a mobile phone ban is either negative or positive on exam results, either for schools in total, males or females.

Table 1: Rollout Estimates: All Schools

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Mean		Mean		Mean	
Exam Results	pre-ban	Total	pre-ban	Male	pre-ban	Female
Mobile phone ban	3.45	0.0068	3.27	0.036	3.63	-0.028
		(0.041)		(0.045)		(0.042)
Controls		✓		✓		✓
Year fixed effects		✓		✓		✓
Municipality fixed effects		✓		✓		✓
Observations		13433		6786		6647
No. of clusters		370		367		363
Dependent variable:	Mean		Mean		Mean	
Well-being	pre-ban	Total	pre-ban	Male	pre-ban	Female
Mobile phone ban	4.23	-0.042*	4.23	-0.050*	4.23	-0.033
		(0.021)		(0.026)		(0.024)
Controls		✓		✓		✓
Year fixed effects		✓		✓		✓
Municipality fixed effects		✓		✓		✓
Observations		11606		5852		5754
No. of clusters		363		354		351
Dependent variable:	Mean		Mean		Mean	
Bullying	pre-ban	Total	pre-ban	Male	pre-ban	Female
Mobile phone ban	1.36	-0.0075	1.41	-0.0069	1.30	-0.0094
		(0.016)		(0.021)		(0.017)
Controls		✓		✓		✓
Year fixed effects		✓		✓		✓
Municipality fixed effects		✓		✓		✓
Observations		11655		5876		5779
No. of clusters		363		354		351

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Each parameter is from a separate regression of a mobile phone ban on the outcome variables, based on the model in Equation (1). Outcome variables are exam results, self-reported well-being, and self-reported bullying. The mean in column (1), (3) and (5) are means for all schools in the total, male and female sample, pre-mobile phone ban. For exam results, the mean grade pre-ban is the mean grade in Norwegian, and subject controls for mathematics and English are included. Other control variables are school size and student-teacher ratio. Standard errors are clustered at the school level. The analysis period is from 2007 to 2017.

Previous chapters have emphasized the possible effect of mobile phones on mental health and exclusion. Table 1 further presents the estimated effects of a mobile phone ban on self-reported well-being at school. We find that well-being is overall negatively affected by a mobile phone ban, and that the effect is slightly larger for the male sample. The estimated effect of a ban is significant at a 10% level, with a 0.9% and 1.2% decrease in well-being for the total and male sample respectively. We may see negative effects on well-being because lonely children are more exposed when not being able to use their phones. This effect of a ban was found in the Norwegian study Fritze et al. (2017). The estimates for the female sample are not significant. This result may be unexpected, as females are reported to use their phones more (Medietilsynet, 2018), and potentially could react more to being deprived of their phones. This could either way confirm that male and female students do use their mobile phones differently. It is, however, important to note that the effects are not large and that a 10% significance level provides uncertainty about the estimates.

Table 1 lastly shows the effect of a mobile phone ban on self-reported bullying. We see that for all three samples, a mobile phone ban is connected with a small decline in bullying. The effect is however insignificant in all three regressions.

All regressions have standard errors clustered at the school level. We present the same regressions with clusters at municipality and county level in Table A8 in the Appendix. The standard errors are relatively similar when clustering at different levels. For the remaining part of the analysis, we continue to cluster the standard errors at the school level.

6.1.2 Only Ban Schools

Figure 3 in Chapter 4 showed that exam results for schools with and without bans differed between 2007 and 2017. This may indicate that there could be persistent differences between the ban schools and no ban schools.

This leads us to the next part of the analysis, where we look at ban schools only and exploit the timing of the introduction of a ban. The estimated effect of a mobile phone ban can now be interpreted as the effect of the timing of the ban. The treatment group is still the schools who have implemented a ban, while the control group consists of the same schools in advance of implementation.

Table 2 presents the estimates from the same regressions as above, but with the restricted sample. We see that compared to the results in Table 1, the estimated effect of imple-

menting a ban on exam results has changed from positive to negative for the total and male sample. The estimates are however not significant. Table 2 further presents the estimates for well-being on the subset of schools who have implemented a ban. For this sample, the signs are still negative, but we lose significance.

Lastly, Table 2 presents the effect of a mobile phone ban on bullying. The coefficient of interest, implementation of ban, has both increased in size and become significant for the total and male sample compared to the results in Table 1. For the total sample, the implementation of a ban is connected with a 0.026 point decrease, or 1.9%, in self-reported bullying. This effect is significant on a 10% level. For the male students, this effect is both larger and significant on a 5% level. The effect is not significant for the female sample. In their yearly report, Medietilsynet (2018) find that male students are bullied more than female students. They also report an increase in male students being affected by online bullying. The estimates in column (2) show that for the schools implementing bans, the actual removal of mobile phones decreased bullying for male students with 0.039 points on the 1 to 5 scale, or 2.7%.

We have done further analyses on the sub sample of schools introducing a ban. As discussed in previous chapters, there are both public and private schools in our total sample. When looking at this sub sample of only ban schools, we find that the share of private schools has increased compared to the original sample. We are investigating whether the effect of a ban changes when removing these schools from the sample. We further check whether private schools benefit differently from a mobile phone ban than public schools, using the specification in Equation (2) from Chapter 5. Lastly, we test whether our estimates change when we include weights for school size.

Table 3 shows the estimated effect of a mobile phone ban on exam results with the specifications mentioned above. The first estimated effect of interest is reported in column (3). This is the estimated effect of a ban when we remove all private schools from the sample. The negative effect of the timing of a ban is larger for public schools than in the baseline regression, but it does not change significance. This may indicate that private schools and public schools experience different effects of a ban. Column (4) shows that this might, in fact, be the case. Here, the private schools are again a part of the sample. We see that the private schools on average experience significantly higher exam results than the public schools. We see from the interaction term that as private schools implement a ban, they increase their exam results with 0.18 points on average, against the base of being a public school. This effect may simply be driven by the fact that private schools are performing better than public schools. The true effect of a private school introducing a mobile phone ban is the added effect of implementation and the interaction

Table 2: Rollout Estimates: Schools With Ban

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Mean		Mean		Mean	
Exam Results	pre-ban	Total	pre-ban	Male	pre-ban	Female
Implementation of ban	3.43	-0.018	3.26	-0.0035	3.61	-0.037
		(0.022)		(0.027)		(0.025)
Controls		✓		✓		✓
Year fixed effects		✓		✓		✓
Municipality fixed effects		✓		✓		✓
Observations		8420		4260		4160
No. of clusters		251		249		245
Dependent variable:	Mean		Mean		Mean	
Well-being	pre-ban	Total	pre-ban	Male	pre-ban	Female
Implementation of ban	4.22	-0.029	4.22	-0.024	4.22	-0.032
		(0.018)		(0.022)		(0.021)
Controls		✓		✓		✓
Year fixed effects		✓		✓		✓
Municipality fixed effects		✓		✓		✓
Observations		7233		3646		3587
No. of clusters		246		238		236
Dependent variable:	Mean		Mean		Mean	
Bullying	pre-ban	Total	pre-ban	Male	pre-ban	Female
Implementation of ban	1.36	-0.026*	1.42	-0.039**	1.31	-0.013
		(0.014)		(0.018)		(0.016)
Controls		✓		✓		✓
Year fixed effects		✓		✓		✓
Municipality fixed effects		✓		✓		✓
Observations		7256		3658		3598
No. of clusters		246		238		236

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Each parameter is from a separate regression of a mobile phone ban on the outcome variables, based on the model in Equation (1). Outcome variables are exam results, self-reported well-being, and self-reported bullying. The mean in column (1), (3) and (5) are means for ban schools in the total, male and female sample, pre-mobile phone ban. For exam results, the mean grade pre-ban is the mean grade in Norwegian, and subject controls for mathematics and English are included. Other control variables are school size and student-teacher ratio. Standard errors are clustered at the school level. The analysis period is from 2007 to 2017.

term, and results in a positive effect on exam results of 0.156 points, or 4.3%. This effect is significant at a 10% level. In column (5), the estimated effects when weighting for school size are reported. The effect of a ban is larger than for the baseline sample, but it is not significant.

Table 3: Rollout Estimates: Exam Results, Schools With Ban

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Mean		Public	Private	
Exam Results	pre-ban	Baseline	schools	interaction term	WLS
Implementation of ban	3.43	-0.018	-0.030	-0.024	-0.046
		(0.022)	(0.022)	(0.022)	(0.028)
Private school				0.20***	
				(0.074)	
Implemented at				0.18**	
private school				(0.073)	
Controls		✓	✓	✓	✓
Year fixed effects		✓	✓	✓	✓
Municipality fixed effects		✓	✓	✓	✓
Weights					✓
Observations		8420	8207	8420	8420
No. of clusters		251	233	251	251

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Each column represents a separate regression of a mobile phone ban on the outcome variable, based on the model in Equation (2). The outcome variable is exam results. The mean in column (1) is a mean for ban schools in the total sample, pre-mobile phone ban. The mean grade pre-ban is the mean grade in Norwegian, and subject controls for mathematics and English are included. Other control variables are school size and student-teacher ratio. Standard errors are clustered at the school level. The analysis period is from 2007 to 2017.

Table 4 shows the same regressions as above, but with well-being as the dependent variable. Here, we see no large difference between the baseline effect and the effect when excluding private schools. From column (4), we see that private schools have significantly and substantially higher scores on well-being than public schools. The private schools implementing a ban do, however, not experience a significant change in well-being after implementing a ban. When weighting for school size, there is no large change in the estimated effect of a ban on well-being, which is good.

Table 5 shows the estimated effect of a mobile phone ban on bullying, still with the same specifications as above. From column (3) and (5), we see no particular change in the estimated effect when excluding private schools and using WLS, respectively. Column (4)

Table 4: Rollout Estimates: Well-being, Schools With Ban

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Mean		Public	Private	
Well-Being	pre-ban	Baseline	schools	interaction term	WLS
Implementation of ban	4.22	-0.029	-0.025	-0.028	-0.025
		(0.018)	(0.019)	(0.019)	(0.019)
Private school				0.12***	
				(0.037)	
Implemented at				0.017	
private school				(0.038)	
Controls		✓	✓	✓	✓
Year fixed effects		✓	✓	✓	✓
Municipality fixed effects		✓	✓	✓	✓
Weights					✓
Observations		7233	7061	7233	7233
No. of clusters		246	228	246	246

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Each column represents a separate regression of a mobile phone ban on the outcome variable, based on the model in Equation (2). The outcome variable is well-being. The mean in column (1) is a mean for ban schools in the total sample, pre-mobile phone ban. Control variables are school size and student-teacher ratio. Standard errors are clustered at the school level. The analysis period is from 2007 to 2017.

shows that when including private schools, but controlling for them, the estimated effect of a ban is equal to the baseline estimate. Private schools have significantly lower bullying than public schools. Private schools further get a significant reduction in bullying from implementing a ban of 0.11 points, an effect which is significant on a 1% level. This is the added effect of implementation and the interaction term. The estimated effect is a 8.7% reduction, which is a large effect.

Table 5: Rollout Estimates: Bullying, Schools With Ban

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Mean		Public	Private	
Bullying	pre-ban	Baseline	schools	interaction term	WLS
Implementation of ban	1.36	-0.026*	-0.026*	-0.026*	-0.028*
		(0.014)	(0.014)	(0.014)	(0.014)
Private school				-0.098***	
				(0.019)	
Implemented at				-0.084***	
private school				(0.025)	
Controls		✓	✓	✓	✓
Year fixed effects		✓	✓	✓	✓
Municipality fixed effects		✓	✓	✓	✓
Weights					✓
Observations		7256	7084	7256	7256
No. of clusters		246	228	246	246

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Each column represents a separate regression of a mobile phone ban on the outcome variable, based on the model in Equation (2). The outcome variable is bullying. The mean in column (1) is a mean for ban schools in the total sample, pre-mobile phone ban. Control variables are school size and student-teacher ratio. Standard errors are clustered at the school level. The analysis period is from 2007 to 2017.

6.2 Findings Event Study

As mentioned in Chapter 5, our analysis depends on the assumption that there are no underlying trends determining the implementation of a mobile phone ban. The rollout estimates do not show whether the introducing schools chose to implement a ban because they experienced certain tendencies in the outcome variables, or if there are differences in the schools who implement early and the schools who implement late. To test this, we use the event study specification from Equation (3) on our three outcome variables; exam results, well-being and bullying.

6.2.1 Exam Results

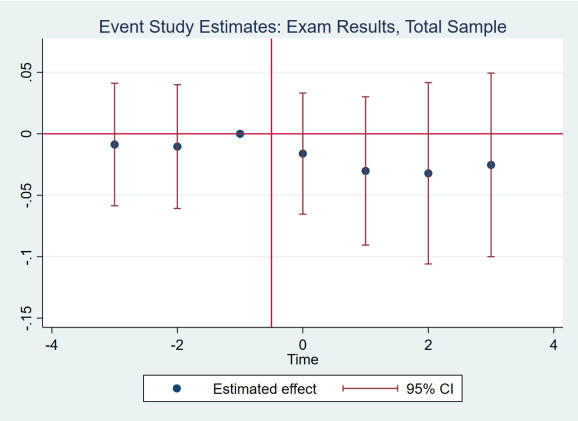
The estimated results for the total sample, male and female sample can be found in Figures 5a, 5b, and 5c. The three regressions that form the basis for these plots include the same controls and fixed effects as the rollout specification. We show the estimated effect of a mobile phone ban in a time window from three years prior to three years after the implementation. Note that observations more than three years before or three years after implementation of a ban are also included in this time window, as explained in Chapter 5.2. The plots also visualize the confidence intervals connected with every estimated coefficient.

For all samples, we find no evidence of particular pre-trends. The estimated effects of the treatment on exam results lie very close to zero before the implementation. Looking at the development in estimates after year zero, we see that for the total and the male sample, the effect increases from year zero to year two. After this, the effect is smaller. This might indicate that a mobile phone ban has the largest effect on those being exposed to a *change* in policy. The effect decreases with time, implying that the cohorts who have had a mobile phone ban during all of lower secondary school experience a smaller effect of the ban. However, none of the effects are significantly different from zero in the post-treatment period, ie. we do not find a significant effect of a mobile phone ban on exam results.

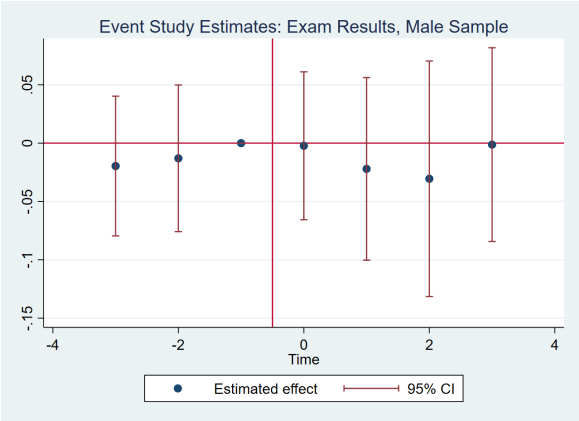
6.2.2 Well-Being

Figures 6a, 6b and 6c show the event study estimations for well-being as the outcome variable. The regressions that form the basis for these estimates consist of the same control variables and fixed effects as the rollout specification.

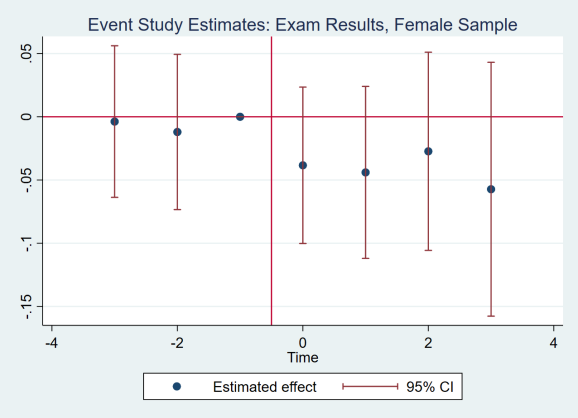
Figure 5: Event Study Estimates: Exam Results



(a) Exam Results, Total Sample



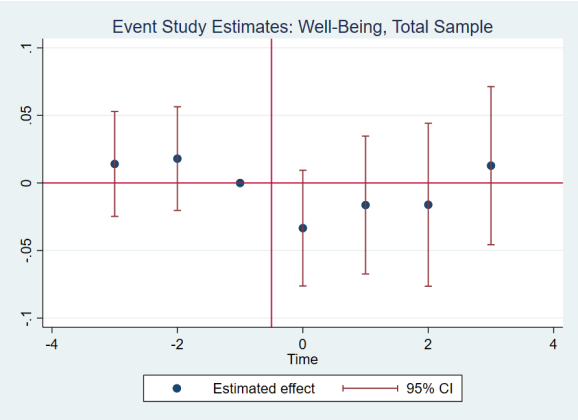
(b) Exam Results, Male Sample



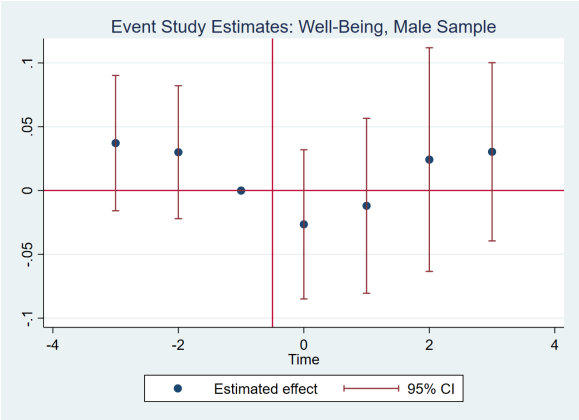
(c) Exam Results, Female Sample

Notes: The figures plot the anticipatory and post-treatment effects from the event study specification in Equation (3). For exam results, the mean grade pre-ban is the mean grade in Norwegian, and subject controls for mathematics and English are included. Other control variables are school size and student-teacher ratio. Year fixed effects and municipality fixed effects are included. Standard errors are clustered at a school level.

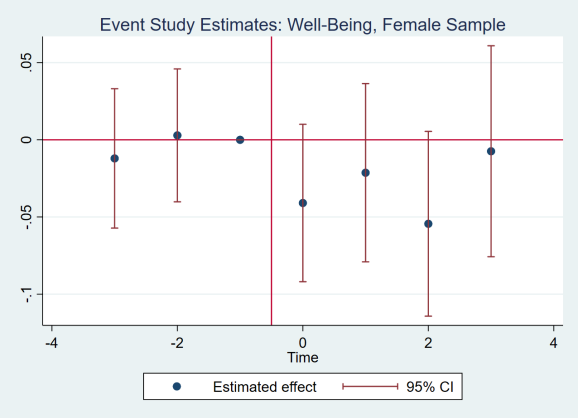
Figure 6: Event Study Estimates: Well-Being



(a) Well-Being, Total Sample



(b) Well-Being, Male Sample



(c) Well-Being, Female Sample

Notes: The figures plot the anticipatory and post-treatment effects from the event study specification in Equation (3). Control variables included are school size and student-teacher ratio. Year fixed effects and municipality fixed effects are included. Standard errors are clustered at a school level.

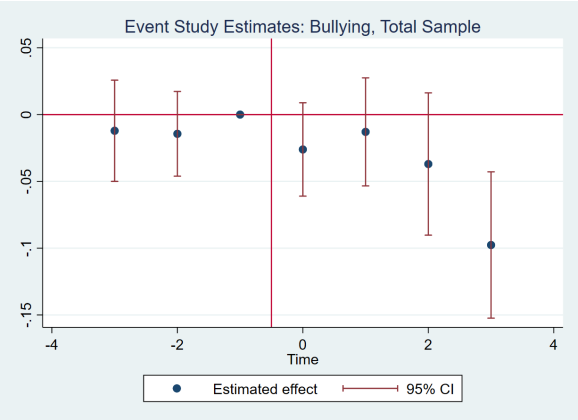
As with exam results, we do not find any significant pre-treatment estimates, implying that the post-implementation estimates are not driven by the pre-treatment period. Looking at the trends in well-being after implementing a mobile phone ban, it may seem like self-reported well-being falls most in the year of the treatment. After this, the effect decreases, and it seems like well-being improves after a while after implementation. This might indicate that the ban has the most effect on the cohort of students who are being deprived of their phones when they are in their third year of lower secondary school, which is when they answer the Pupil Survey. Students are less likely to be displeased if the school has had a ban the entire period they were there. This seems somewhat like a trend for male students and a more ambiguous effect for female students. The estimated effects of the treatment are however not significant for any of the samples, and thus we cannot conclude that this is, in fact, the case.

6.2.3 Bullying

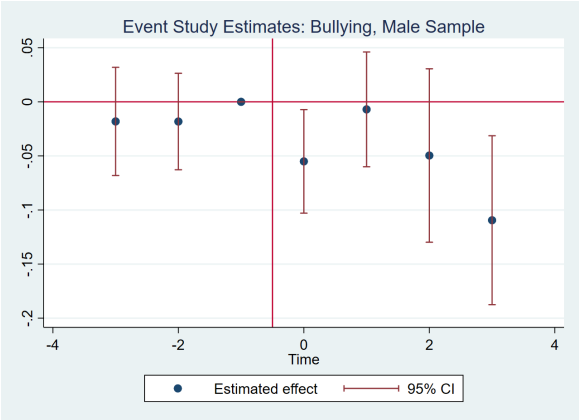
Figures 7a, 7b and 7c show the event study estimates for bullying as the outcome variable. As with the previous estimates, the regressions that form the basis for these estimates consist of the same control variables and fixed effects as the rollout specification.

The pre-treatment estimates for these last plots are not significant either, indicating that the schools who implement a mobile phone ban were not on a particular trend in bullying prior to implementation. After introducing a ban, we see a decreasing trend in bullying. For the total and the female sample, this effect is mainly downward sloping and significant if a ban has been implemented for three years or more. For the male sample, this effect is additionally significant in the treatment year. We can therefore reject the hypothesis that there is no effect of mobile phone bans on bullying. We find that introducing a mobile phone ban decreases bullying and that it has the most effect on the cohort of students who have had a ban continuously through lower secondary school.

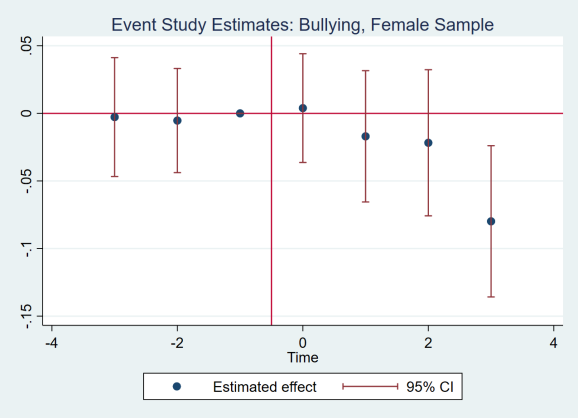
Figure 7: Event Study Estimates: Bullying



(a) Bullying, Total Sample



(b) Bullying, Male Sample



(c) Bullying, Female Sample

Notes: The figures plot the anticipatory and post-treatment effects from the event study specification in Equation (3). Control variables included are school size and student-teacher ratio. Year fixed effects and municipality fixed effects are included. Standard errors are clustered at a school level.

6.3 Remarks on the Results

We find no evidence for mobile phone bans affecting the students' academic performance in the full and restricted sample for the baseline specifications. When we test whether introducing a ban affects private and public schools differently, we find a weak positive effect of a ban on academic results for private schools.

When looking at well-being for the full sample, we find that schools with mobile phone bans experience a weakly significant lower well-being than those without. As ban schools and no ban schools might have different characteristics, the effect of the timing is of most interest. When examining the restricted sample of only introducing schools, we lose significance for all specifications.

The estimates for the effect of a mobile phone ban on bullying are interesting. When looking at the restricted sample of only schools having implemented a ban, we see that the introduction of a ban has a weakly significant, negative effect on bullying. Schools who implement a ban experienced less bullying after the ban. The effect on male students is both stronger than for the total sample and significant on a 5% level. We find that private schools received a relatively large reduction in bullying after implementing a ban. This effect is significant at a 1% level. The event study estimates indicate no evidence for pre-trends driving the results.

These findings lead us to conclude that schools introducing mobile phone bans cannot expect large effects on either exam results or well-being. Nevertheless, a reduction in bullying can be expected, not immediately, but rather after some years.

7 Robustness Checks

To test whether our analysis is sensitive to changes, we perform a robustness check. We expand the definition of a ban to include those schools who ban phones only during class, but not during recess, and investigate whether this affects our conclusions.

7.1 Changing the Definition of a Ban

For the main analysis, we have used a strict definition of a mobile phone ban. Only schools where the students have no access to their phone were defined as being treated. Given our hypothesis that mobile phones are distracting in a lecture setting, which might again affect results, it may be that our definition of a ban is too strict. Schools where students have no access to their phones during class, but have access during recess, might experience similar effects of a ban on exam results as those banning phones the entire day. Based on this reasoning, we expand the definition of a ban to also include policies where the students have access to their phones during recess. We would expect to see similar effects on exam results and well-being when expanding the ban, as before. The effect of this less strict ban on bullying might, on the other hand, be different. This might, for example, be because it is likely that cyberbullying is more frequent during recess.

The sample we use once again consists of only the schools ever implementing a ban, previously called ban schools. This sample has now increased in size, with 77 additional schools, because a majority of the schools fall within this category when expanding the definition. We perform the analysis to investigate the effect of the timing of a ban. From Table 6, we see no change in significance for exam results when expanding the definition of a ban. This is in accordance with our expectations. There are some changes in magnitude and sign, but we find no proof that having access to mobile phones in recess has changed the effect of a classroom ban on results. For well-being, we draw the same conclusion. Allowing for recess access did not change either sign or significance. Although the effects are still negative, the estimated coefficients are somewhat smaller with the expanded ban.

Table 6 further shows the estimated effect of a ban on bullying when expanding the definition. We lose significance when investigating the effect of a non-strict ban. In Table 2 on page 29, we saw that bullying was significantly reduced after a mobile phone ban was implemented. When students are allowed to use their phones during recess, the effect of a ban on bullying is smaller in size and no longer significant. This result is interesting, as it implies that schools need to ban phones completely if they want to reduce bullying, not

Table 6: Rollout Estimates: Expanded Definition of Ban, Schools With Ban

Dependent variable:	(1)	(2)	(3)
Exam Results	Total	Male	Female
Implementation of ban	-0.0066	0.0040	-0.020
	(0.023)	(0.027)	(0.025)
Controls	✓	✓	✓
Year fixed effects	✓	✓	✓
Municipality fixed effects	✓	✓	✓
Observations	11628	5875	5753
No. of clusters	328	325	321
Dependent variable:			
Well-Being	Total	Male	Female
Implementation of ban	-0.0074	-0.0083	-0.0059
	(0.014)	(0.018)	(0.016)
Controls	✓	✓	✓
Year fixed effects	✓	✓	✓
Municipality fixed effects	✓	✓	✓
Observations	10033	5060	4973
No. of clusters	321	312	309
Dependent variable:			
Bullying	Total	Male	Female
Implementation of ban	-0.013	-0.019	-0.0080
	(0.010)	(0.014)	(0.012)
Controls	✓	✓	✓
Year fixed effects	✓	✓	✓
Municipality fixed effects	✓	✓	✓
Observations	10069	5078	4991
No. of clusters	321	312	309

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Each parameter is from a separate regression of a mobile phone ban on the outcome variables, based on the model in Equation (1). Outcome variables are exam results, self-reported well-being, and self-reported bullying. For exam results, the base subject is Norwegian, and subject controls for mathematics and English are included. Other control variables are school size and student-teacher ratio. Standard errors are clustered at the school level. The analysis period is from 2007 to 2017.

only during class. This finding supports many participants in the debate about mobile phone bans, who claim that a strict ban strengthens the school environment. Many of the principals replying to the comment section in our survey advocate a strict ban because they see students connecting better with each other. We find it likely that there could be a link between students getting better at interacting with each other and lower self-reported bullying.

The results reported in Table 6 shed new light on the potential effect of mobile phones on bullying. However, it is possible that these effects are caused by the extension of the sample to include more schools, rather than the effect of recess access itself.

To test whether this might be the case, we perform a last analysis. We keep the same sample of schools as in Table 6 but use the original strict definition of a ban. This implies that schools with recess access are always in the control group, while schools with a strict ban become treated upon implementation. Compared to Table 6, all the 77 additional schools are now in the control group. The estimated results are reported in Table 7.

In fact, Table 7 shows similar estimates as the first regression we conducted, see Table 1 on page 26. Hence, when adding the schools with the less strict ban to the control group, there is no longer the effect of a ban on bullying that we found in Table 2. One reason for this finding could be that these schools are somewhat different, as shown in Table A7 in the Appendix, where we list descriptive statistics for strict versus non-strict ban schools.

Table 7: Rollout Estimates: Expanded Sample, Schools With Ban

Dependent variable:	(1)	(2)	(3)
Exam Results	Total	Male	Female
Implementation of ban	0.0047	0.030	-0.028
	(0.048)	(0.053)	(0.050)
Controls	✓	✓	✓
Year fixed effects	✓	✓	✓
Municipality fixed effects	✓	✓	✓
Observations	11628	5875	5753
No. of clusters	328	325	321
Dependent variable:			
Well-Being	Total	Male	Female
Implementation of ban	-0.041*	-0.054*	-0.026
	(0.024)	(0.029)	(0.027)
Controls	✓	✓	✓
Year fixed effects	✓	✓	✓
Municipality fixed effects	✓	✓	✓
Observations	10033	5060	4973
No. of clusters	321	312	309
Dependent variable:			
Bullying	Total	Male	Female
Implementation of ban	-0.0056	-0.0024	-0.0092
	(0.018)	(0.024)	(0.019)
Controls	✓	✓	✓
Year fixed effects	✓	✓	✓
Municipality fixed effects	✓	✓	✓
Observations	10069	5078	4991
No. of clusters	321	312	309

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Each parameter is from a separate regression of a mobile phone ban on the outcome variables, based on the model in Equation (1). Outcome variables are exam results, self-reported well-being, and self-reported bullying. The control group consists of the schools allowing the students to use their phones during recess, but not otherwise. The treatment group is those schools having implemented a total ban. For exam results, the base subject is Norwegian, and subject controls for mathematics and English are included. Other control variables are school size and student-teacher ratio. Standard errors are clustered at the school level. The analysis period is from 2007 to 2017.

8 Discussion

In our analysis, we found that the introduction of mobile phone bans did not result in significant changes in exam results or well-being, but that there might be effects on bullying. In this chapter, we discuss potential weaknesses of the analysis and implications of the thesis. First, we discuss shortcomings of the data set. Further, we look at implications of the chosen estimation strategy, and how this might impact the results. Lastly, we discuss where we think the research on this topic needs to go from here, as well as what contribution this thesis provides.

8.1 Limitations to the Data Set

Our data set only contains school level data. Ideally, we would wish to look at individual level data, as this could have provided us with more of the underlying variation at each school. It would also have increased the number of observations substantially, and thus reduced the risk of errors in estimation. Individual characteristics could further be important determinants of our outcome variables. Not being able to control for these could cause omitted variables bias in our estimated model.

There might further be potential problems with the survey data. We know that many schools often change their mobile phone policy and that teachers at each school do not always enforce the regulations as said. If the students do not comply with the mobile phone policy, we would risk estimating the effect of a ban incorrectly. This could, for example, be if students bring two phones to school, one to hand in and one to keep. We know that this might be a realistic problem, as it has been mentioned both in the comment section in the survey and in the media.

The data from the Pupil Survey might have potential weaknesses. As mentioned in Chapter 4, some of the questions in the survey changed slightly after 2012. Before 2012, students were asked whether they liked it *well* at school, while they after 2012 were asked whether they like it at school. It may be that the students report a higher well-being after 2012, as this new question could be easier to relate to. For bullying, there was also a change in the question. Before 2012, the students were asked whether they had been bullied at school. After 2012, this changed to whether they had been bullied *by other students* at school. This means that before 2012, students might report more bullying, for example if they felt bullied by a teacher or other adults at school. If these changes in questions affect schools differently, it could be a problem for the analysis.

8.2 Limitations to the Analysis

If the decision to implement a mobile phone ban is connected with unobservable determinants of academic results, well-being or bullying, this could cause endogeneity problems. One example of this could for example be the use of tablets. We do not have data on whether the schools in our sample have tablets for their students and have not analyzed how the use of tablets in Norwegian schools has affected our outcome variables. The literature presented in Chapter 3 demonstrated that proper implementation of technology in education could have positive effects. Many schools and municipalities have bought tablets for every student to use in class (NRK, 2018). Beneficial use of these tablets could make mobile phones as learning tools excess, potentially making it easier to justify a phone ban. If the schools ban phones and introduce tablets at the same time, this could make the estimated effect of a mobile phone ban inaccurate, as we could expect the use of tablets to affect academic results. If the schools in our sample use their tablets poorly, this could mask a positive effect of a mobile phone ban on results. On the other hand, if the schools buy tablets and use these well, while at the same time banning phones, this could underestimate a potentially negative effect of a ban on results.

Further, schools might have answered the alternative closest to their respective policy, although it did not fit entirely. We risk that schools answering either that mobile phones are prohibited on school premises, or that mobile phones should be turned off at all times or be in "mobile phone hotels", might, in fact, use mobile phones in class for educational purposes. This might hurt our identification. We have taken it as given that the schools have answered as correctly as possible.

8.3 Limitations to the Estimation Strategy

We have used written exam results as a measure of learning in this thesis. The reason for this is that a written exam is the most objective way of measuring how well Norway's 10^{th} graders master the curriculum. However, Udir gathers more information about the students' academic performance at the end of lower secondary school. The overall assessment grade is decided by the relevant teacher in each subject and should reflect how well the student has performed in the subject through the year (Udir, 2018a). It might be that this grade is more sensitive to changes in the mobile phone policy at school. In a scenario where a school does not have a mobile phone ban, the teachers' attitudes towards students and their performance could be affected by disturbance from phones. This could potentially affect the overall assessment grades negatively. This effect could be reduced if the school bans mobile phones completely. With this in mind, overall assessment grades

could also prove as a relevant outcome variable when examining the effect of a phone ban on learning. It could also be relevant to compare the effect on exam results to the effect on overall assessment grades to isolate the effect of teachers' attitudes towards phones.

8.4 Implications of the Thesis

In this thesis, we add to the literature by looking at the effect of strict mobile phone policies on well-being and bullying. We also replicate the Beland & Murphy (2016) study using Norwegian school level data on academic performance. Looking at these three outcomes in the same context can have implications for schools considering introducing a mobile phone ban. Note that our conclusions apply mainly for schools who have implemented a ban.

We find no effect of a ban on academic results. Schools who wish to ban mobile phones to increase the mean grade on written exams, should therefore potentially consider other actions first. It may take up time and resources to enforce a complicated policy, resources that could be spent more wisely on other measures known to have an effect on academic results. Our results differ from Beland & Murphy (2016), who find positive effects of banning phones. It might be that Norwegian students experience a mobile phone ban differently than English students. On the other hand, Beland & Murphy have used another measure for academic performance than us and have also used individual rather than school level data. This implies that we might have found similar effects had we used the same type of test scores and examined data on the same level.

Research suggests that mobile phone usage can have negative effects on young people's mental health, and advocates for mobile phones to be less present in their everyday life (Twenge et al., 2018; Elhai et al., 2017). Many of the principals who answered our survey reported well-being as one of the main motivations for their ban. Our estimates, however, do not find a positive effect of removing mobile phones on well-being. The effect is rather ambiguous, indicating that the same conclusion applies for this as for academic performance. If a school's main ambition is to increase self-reported well-being among its students, other measures than a mobile phone ban should perhaps be implemented first.

This thesis has implications for how schools can work to reduce self-reported bullying. By implementing strict mobile phone bans, schools can significantly reduce bullying after some time. This further implies that new schools should consider banning phones from the beginning to get immediate effects on bullying. We also see that the effect of a mobile phone ban is particularly strong for the male students. As male students on average

report more bullying than female students, it is important to note which measures work to reduce bullying among boys.

8.5 Further Research

This study is limited to looking at the various effects of a mobile phone ban on the average exam results and Pupil Survey scores at lower secondary schools in Norway. Further research on this topic should exploit individual level data. This could enable the analysis of a mobile phone ban on different types of students, to examine whether there are different effects on the parts of the distribution. By using individual level data, one could investigate the effect of a ban on high- and low-performing students in Norway, as Beland & Murphy (2016) did with English data. Investigating whether weaker students are in fact driving the effect of a ban on results, could potentially be important in a debate about inequality and education. By using individual level data, it would also be possible to control for factors determining academic results, for example ethnic background or parents' education level.

Bullying continues to be a prevalent problem at Norwegian schools. Any research contributing to the literature on which measures work and not, would be important. Related to this thesis, investigating how a mobile phone ban affects the students who report of most and least bullying, could thus be of interest. This analysis would be enabled by having access to individual level data.

Furthermore, research should focus on the difference between using tablets or mobile phones as learning tools. Both have the possibility of being properly integrated in the educational setting and offer endless opportunities of new learning methods. Mobile phones have the additional feature that it is personalized and works as a bring-your-own-device. It is natural that the schools will have more control over the apps the students use at the schools' tablets than they do when the students use their own phones. If the students, for example, have access to messaging apps when using phones, this could potentially be distracting. On the other hand, if there is no significant effect of tablets over mobile phones, this could be an argument for saving resources on buying tablets and have the students bring their phones to school instead.

Lastly, we are bound by the fact that most schools only implemented a mobile phone ban recently. This allows for many observations in the pre-treatment period, but fewer in the post-treatment period. Further research should be done on the effects of a mobile phone ban on relevant outcome variables when more post-treatment observations are available. This would potentially strengthen the estimated effects. It would furthermore

be interesting to examine the long-term effects of a ban.

9 Conclusions

In this thesis, we aim to answer the following research question:

How has the introduction of mobile phone bans in Norwegian lower secondary schools affected academic performance, well-being, and bullying?

Norwegian schools have full autonomy in choosing their own mobile phone policy. Many have chosen to introduce mobile phone bans in later years, but there is no national record of these bans. For the purpose of mapping the schools' mobile phone policies, we circulate a survey to all lower secondary schools. We receive usable data from 493 schools, a response rate of 39%, which we link with data on written exam results and scores on the Pupil Survey from 2007 to 2017. To analyze the effect of a mobile phone ban on our outcome variables, we exploit the differences in the timing of introduction of bans across the country. We are able to detect a causal effect of the implementation of a mobile phone ban on student outcomes by using a generalized differences-in-differences approach and an event study specification.

Our findings suggest no overall effect of the implementation of a mobile phone ban on academic performance. Our estimates thus differ from previous literature finding positive effects of a mobile phone ban on test results. Still, our findings are in accordance with other studies finding ambiguous effects of technology in school on academic performance. When examining only the schools implementing a ban, we find that private schools see positive effects of a ban on academic performance. The effect of a ban on well-being is non-significant. Furthermore, we detect a significant causal effect of a mobile phone ban on bullying. The implementation of a ban is connected with a 1.9% decrease in bullying. For male students, the effect is a decrease of 2.8%. For private schools, we find a 8.7% decrease in bullying after the implementation of a mobile phone ban.

One of the main motivations for writing this thesis was the debate on whether a national mobile phone ban should be implemented in Norway. As a contribution to this debate, we found it important to shed light on more than the academic aspect of a ban. Our findings indicate that the effect of a ban on bullying could be a potential argument for initiating a national ban on mobile phones. The effects on academic performance and well-being are not significant and should perhaps not be emphasized in this regard. It is, however, important to note that we only measure the effect of a ban on student outcomes on a school level. Further research should use Norwegian individual level data to measure the effects more accurately.

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10 Appendix

Table A1: List of Control Variables

Name	**Description**
Subject controls	Equal to 1 if the subject is either mathematics or English.
School size	Number of students at a school.
Student-teacher ratio	Relationship between number of student hours and number of teacher hours. This variable gives information on class size. It further includes hours dedicated to special education.

Survey Questions

The survey questions were circulated in Norwegian. Here, we refer both a translation and the original questions for reference.

English Version

1. Which school are you answering on behalf of?
2. Which alternative best describes your school's mobile phone policy?
    - Mobile phones are not allowed on school premises
    - Mobile phones are allowed, but should always be turned off or kept in "mobile phone hotels"
    - Mobile phones are allowed, but should always be in silent mode and turned off during class
    - Mobile phones are allowed, but should always be in silent mode
    - Mobile phones are allowed, but should not be disturbing during class
    - No mobile phone policy
    - Other
3. If "other", what mobile phone policy do you have?
4. Which year was your present mobile phone policy introduced?
5. Has your rector changed since after you changed your mobile phone policy?
6. If yes, when did you change rector?
7. Did you have another mobile phone policy before your present policy?
8. If yes, which alternative best describes your previous mobile phone policy?
    - Mobile phones are not allowed on school premises
    - Mobile phones are allowed, but should always be turned off or kept in "mobile phone hotels"
    - Mobile phones are allowed, but should always be in silent mode and turned off during class
    - Mobile phones are allowed, but should always be in silent mode

- Mobile phones are allowed, but should not de disturbing during class
- No mobile phone policy
- Other

9. Do you have any other questions or comments?

Original Version

1. Hvilken skole svarer du på vegne av?
2. Hvilket alternativ beskriver best skolens mobilreglement?
    - Mobil er ikke tillatt på skolens område
    - Mobil er tillatt, men skal alltid være avslått eller være i "mobilhotell"
    - Mobil er tillatt, men må alltid være i stillemodus og avslått i alle timer (kan brukes i friminuttet)
    - Mobil er tillatt, men må alltid være i stillemodus
    - Mobil er tillatt, men skal ikke forstyrre undervisningen
    - Ingen regler
    - Annet
3. Hvis "Annet", hva slags mobilreglement har dere?
4. Hvilket år ble dagens mobilreglement innført?
5. Har dere fått ny rektor etter at dagens mobilreglement ble innført?
6. Hvis "Ja", hvilket år fikk dere ny rektor?
7. Hadde dere et annet mobilreglement før dagens reglement ble innført?
8. Hvilket alternativ beskriver best skolens tidligere mobilreglement?
    - Mobil er ikke tillatt på skolens område
    - Mobil er tillatt, men skal alltid være avslått eller være i "mobilhotell"
    - Mobil er tillatt, men må alltid være i stillemodus og avslått i alle timer (kan brukes i friminuttet)
    - Mobil er tillatt, men må alltid være i stillemodus

- Mobil er tillatt, men skal ikke forstyrre undervisningen
- Ingen regler
- Annet

9. Har du andre spørsmål eller kommentarer?

Figure 8: Share of Children Owning Phones 2014-2018

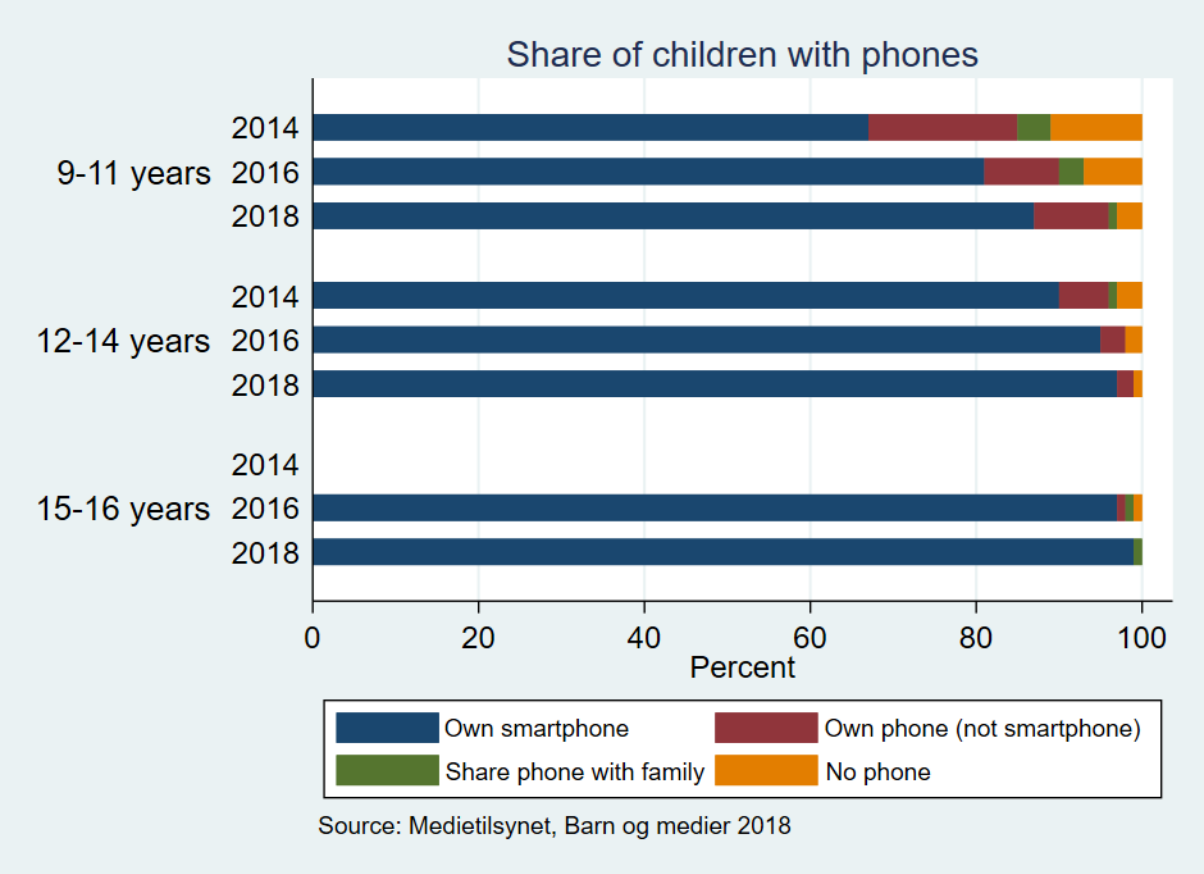

Table A2: Mean Degree of Strictness on New Policies Every Year

	Degree of strictness							
	6	5	4	3	2	1	Total	Mean degree of strictness implemented every year
Always	4	4	4	0	2	1	15	4.3
2000	0	3	2	0	0	0	5	4.6
2001	0	1	0	0	0	0	1	5.0
2002	0	0	0	0	1	0	1	2.0
2005	0	3	0	0	2	0	5	3.8
2006	0	0	2	0	0	0	2	4.0
2007	1	2	0	0	0	0	3	5.3
2008	1	4	2	0	0	0	7	4.9
2009	0	0	1	0	0	0	1	4.0
2010	1	8	5	1	1	0	16	4.4
2011	1	2	0	0	0	0	3	5.3
2012	3	7	4	1	2	0	17	4.5
2013	2	22	7	0	1	0	32	4.8
2014	5	23	10	7	1	0	46	4.5
2015	8	37	12	8	0	0	65	4.7
2016	11	72	17	7	3	0	110	4.7
2017	9	54	18	7	2	0	90	4.7
2018	7	51	10	2	3	0	73	4.8
Total	53	293	94	33	18	1	492	4.5

Notes: "Always" refers to the schools who have replied that they have always had their current mobile phone policy. The mean degree of strictness for these schools is thus how strict the schools who have always had their policy have chosen to be.

Table A3: Mean Test Results Divided by Subject

	Total	Male	Female
Norwegian			
Mean	3.4	3.2	3.7
Std. Dev	(0.468)	(0.368)	(0.375)
Min	1.6	1.6	2.3
Max	5.1	4.7	5.1
Mathematics			
Mean	3.2	3.1	3.3
Std. Dev	(0.525)	(0.533)	(0.505)
Min	1.2	1.2	1.3
Max	5.1	5.1	4.9
English			
Mean	3.7	3.5	3.9
Std. Dev	(0.453)	(0.435)	(0.398)
Min	2	2	2.5
Max	5.2	5.2	5.2
Total			
Mean	3.4	3.3	3.6
Std. Dev	(0.527)	(0.489)	(0.502)
Observations	13477	6809	6668

Notes: Mean grade in a subject refers to the total mean in our sample. The minimum and maximum values are the means at the lowest and highest performing schools respectively.

Table A4: Well-Being and Bullying Full Sample

	Total	Male	Female
Well-being			
Mean	4.22	4.22	4.21
Std. Dev.	(0.22)	(0.22)	(0.22)
Min	3.1	3.1	3.3
Max	4.9	4.9	4.9
Bullying			
Mean	1.34	1.38	1.30
Std. Dev	(0.23)	(0.26)	(0.18)
Min	1	1	1
Max	2.9	2.9	2.5
Observations	11697	5897	5800

Table A5: Public vs. Private Schools

	Public	Private
National share	91.7	8.3
Our sample share	93.8	6.2
Only ban sample share	92.8	7.2
Our sample		
Mean grade	3.5	3.7
Mean well-being	4.2	4.3
Mean bullying	1.3	1.3
Only ban sample		
Mean grade	3.4	3.6
Mean well-being	4.2	4.3
Mean bullying	1.3	1.4

Table A6: Schools With and Without Mobile Phone Bans

	Mean	Obs.
No ban schools		
Mean grade	3.48	5,027
Well-being	4.2	4,387
Bullying	1.3	4,413
School size	164	5.027
Student-teacher ratio	15.5	5,013
Ban schools		
Mean grade	3.43	6,679
Well-being	4.2	5,719
Bullying	1.4	5,742
School size	168	6,679
Student-teacher ratio	15.6	6,653

Notes: No ban schools are defined as schools who never implement a mobile phone ban. Ban schools are defined as those schools who implement a ban sometime during the period of analysis. The mean values for ban schools are means prior to implementation.

Table A7: Schools With Strict and Non-Strict Bans

	Mean	Obs.
Non-strict ban schools		
Mean grade	3.48	3,222
Well-being	4.2	2,814
Bullying	1.3	2,827
School size	165	3,222
Student-teacher ratio	15.6	3,208
Strict ban schools		
Mean grade	3.43	6,679
Well-being	4.2	5,719
Bullying	1.4	5,742
School size	168	6,679
Student-teacher ratio	15.6	6,653

Notes: Non-strict ban schools are defined as schools who implement a non-strict mobile phone ban. Ban schools are defined as those schools who implement a strict ban sometime during the period of analysis. The mean values for non-strict ban schools are means for the entire period of analysis. The mean values for strict ban schools are means prior to implementation.

Table A8: Rollout Estimates: Clustering At Municipality and County Level, All Schools

	Exam Results			Well-Being			Bullying		
Clustering Level:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Municipality	Total	Male	Female	Total	Male	Female	Total	Male	Female
Mobile phone ban	0.0068	0.036	-0.028	-0.042*	-0.050	-0.033	-0.0075	-0.0069	-0.0094
	(0.043)	(0.046)	(0.046)	(0.024)	(0.032)	(0.025)	(0.014)	(0.019)	(0.016)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Municipality fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	13433	6786	6647	11606	5852	5754	11655	5876	5779
No. of clusters	223	221	221	219	213	212	219	213	212

	Exam Results			Well-Being			Bullying		
Clustering Level:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
County	Total	Male	Female	Total	Male	Female	Total	Male	Female
Mobile phone ban	0.0068	0.036	-0.028	-0.042	-0.050	-0.033	-0.0075	-0.0069	-0.0094
	(0.037)	(0.043)	(0.037)	(0.027)	(0.036)	(0.027)	(0.014)	(0.018)	(0.013)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Municipality fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	13433	6786	6647	11606	5852	5754	11655	5876	5779
No. of clusters	18	18	18	18	18	18	18	18	18

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$