Ill Communication:

Technology, Distraction & Student Performance

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Abstract

This paper investigates the impact of removing mobile phones from classrooms. Combining administrative data on student performance with a unique survey of school mobile phone policies in four English cities, we investigate the impact of introducing a ban on mobile phones on student performance, exploiting variations in schools' autonomous decisions to ban these devices. Our results indicate that there is an increase in student performance after a school bans the use of mobile phones and that these gains are driven by the lowest-achieving students. This suggests that restricting mobile phone use can be a low-cost policy to reduce educational inequalities.

JEL classification: I21, I28, 033, J24

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1. Introduction

Technological advancements are commonly viewed as leading to increased productivity. Numerous studies document the benefits of technology on productivity in the workplace and on human capital.[1] There are, however, potential drawbacks to new technologies, as they may provide distractions and reduce productivity. Mobile phones can be a source of great disruption in workplaces and classrooms, as they provide individuals with access to chat software, texting, games, social media and the internet. Given these features, mobile phones can reduce the attention students pay to classes and can therefore be detrimental to learning. There is debate in many countries as to how schools should address the issue of mobile phones. Some advocate for a complete ban while others promote the use of mobile phones as a teaching tool in classrooms.[2] Despite the extensive use of mobile phones by students and the heated debate over how to treat them, the impact of mobile phones on high school student performance has not yet been academically studied.

In this paper, we estimate the effect of schools banning mobile phones on student test scores within schools that implement them. The lack of consensus regarding the impact of mobile phones means that there is no UK government policy about their use in schools. This means that schools have complete autonomy of their mobile phone policy, and have differed in their approaches. We exploit these differences through a difference in differences estimation strategy, using a two-way fixed-effects model. We compare the gains in test scores across and within schools before and after mobile phone bans are introduced. This was accomplished through generating a unique dataset on the history of mobile phone policies from a survey of high schools in four English cities (Birmingham, London, Leicester and Manchester), carried out in spring of 2013. This is combined with administrative data on the complete student population from the National Pupil Database (NPD). Given the long-run nature of the NPD, we know the academic performance of all students from 2001 onwards, and so can use differences in implementation dates of mobile phone bans to measure their impact on student performance. Moreover, the NPD tracks students over time, which allows us to account for prior test scores

[1] E.g: Kruger, 1993; Chakraborty and Kazarosian, 1999; Aral et al., 2007; Ding et al., 2009; and Malamud and Pop-Eleches, 2011.

[2] E.g: Telegraph 2012; Childs, 2013; Barkham and Moss, 2012; Drury, 2012; O'Toole, 2011; Johnson, 2012; and Carroll, 2013.

and a set of pupil characteristics including gender, race, ever eligible for free school meals (FSM), and special educational needs (SEN) status. Although we do not know which individuals owned mobile phones, it is reported that over 90% of teenagers owned a mobile phone during this period in England; therefore, any ban is likely to affect the vast majority of students (Ofcom 2006, 2011).[3]

We find that following a ban on phone use, student test scores improve by 7.64% of a standard deviation. This is driven by the most disadvantaged and underachieving pupils. Students with high prior test scores are neither positively nor negatively affected by a phone ban. Furthermore, our results indicate that there are no significant gains in student performance if a ban is not widely complied with. The results suggest that low-achieving students are more likely to be distracted by the presence of mobile phones, while high achievers can focus in the classroom regardless of the mobile phone policy. Schools could significantly reduce the education achievement gap by prohibiting mobile phone use in schools. We include several robustness checks such as an event study, placebo bans and alternative outcome measures.

The rest of the paper is organized as follows: Section 2 discusses the related literature; Section 3 provides a description of the data, survey and descriptive statistics; Section 4 presents the empirical strategy; Section 5 is devoted to the main results, heterogeneity and robustness checks; and Section 6 concludes with policy implications.

2. Related literature

There is a growing literature on the impact of technology on student outcomes, which has yet to reach a consensus. Fairlie & Robinson (2013) conduct a large field experiment in the US that randomly provides free home computers to students. Although computer ownership and use increase substantially, they find no effects on any educational outcomes. Similar findings have occurred in recent randomized control trials (RCTs) in developing countries where computers are introduced into the school environment (Barrera-Osorio and Linden, 2009; Cristia et al., 2012).

Some studies have found a positive impact from technology, such as Machin et al. (2006), who estimate the impact of information and communication technology (ICT) investment

[3] We further discuss phone ownership rates in Section 3. The focus of this paper is the impact of a school level policy which may have impact on students who own a phone, but also on students who don't own a phone but could still be distracted through the actions of others.

on student outcomes in England, using changes in funding rules as an exogenous shock to investment. They find that ICT investment has a positive effect on student test scores in English and science, but not for mathematics (where computers were rarely used). Barrow et al. (2009) specifically examine the impact of well-structured teaching using computers, and find large (0.17 of a standard deviation) improvements in students' algebra tests.

Specifically relating to mobile phones, Bergman (2012), as part of an RCT, used mobile phones to inform parents of students' homework assignments through texting. The students of parents who were sent messages achieved higher test scores. Fryer (2014) provided free mobile phones for students in Oklahoma City Public Schools in a field experiment. Students received daily information on the link between human capital and future outcomes via text. There were no measureable changes in attendance, behavioural incidents, or test scores.[4] The common theme in these education papers is that the mere introduction of technology has a negligible impact on student test scores, but when incorporated into the curriculum and being put to a well-defined use, technology has the potential to improve student outcomes.

The psychological literature has also found that multitasking is detrimental to learning and task execution in experimental contexts. Recent experimental papers present evidence that mobile phone use while executing another task decreases learning and task completion (e.g. Ophir et al. (2009); Smith et al. (2011); Levine et al. (2013); and Lee et al. (2014)). The distracting nature of mobile phones has been previously examined in other context such as incidence of road accidents. Bhargava and Pathania (2013) exploit a pricing discontinuity in call plans and show that there is a large jump in phone use after 9 p.m. This jump, however, is not followed by an increase in car accidents. Using vehicular fatality data from across the United States and standard difference-in-differences techniques, Abouk & Adams (2013) find that texting bans have only a temporary impact on car accident fatalities, suggesting that drivers react to the announcement of a legislation only to return to old habits shortly afterward.

Our contribution is to estimate the effect of mobile phone bans on high stakes student test scores at the end of compulsory schooling, within schools that implemented them. Our data allows us to investigate which students are most strongly affected by mobile bans by covariates:

[4] However, Fryer (2014) does find that students' reported beliefs about the relationship between education and outcomes were influenced by treatment, and treated students also report being more focused and working harder in school.

gender, prior test scores and whether the student is eligible for free school meal or has special educational need status.

3. Data, mobile phone use and survey

3.1 Student characteristics and performance

The NPD is a rich education dataset of the complete public school population of England.[5] It contains information on student performance and schools attended, plus a range of student characteristics such as gender, age, ethnicity, FSM eligibility and SEN status. Each student is allocated an individual identifier, which allows for the student to be tracked over time and across schools. We generate a dataset that follows students from the end of primary school at age 11 through the end of compulsory school education at age 16, which allows us to condition results based on test scores prior to high school (at age 11). Moreover, we use these information to generate measures of students peer's performance in their previous school. This allows to account for any change in the student population in the school over time, which may be correlated with mobile phone policies.

Students in publicly funded schools follow the National Curriculum. Student's progress through a series of five Key Stages. Our paper focuses on secondary school students and their performance at the end of compulsory education examinations, as such they are high stakes exams and will have long run impacts on labour market outcomes. Students start secondary school at age 11 after completing Key Stage 2 in primary school. Key Stage 3 covers the first three years of secondary school and Key Stage 4 leads to subject-specific exams at age 16, called General Certificates of Secondary Education (GCSEs).

Our main measure of student achievement is based on GCSE test scores from 2001 to 2011. Each GCSE is graded from A* to G, with an A* being worth 58 points and decreasing in increments of six down to 16 for a G grade. Students take GCSEs in different subjects; the mean number of GCSEs (or equivalents) taken in the sample is 9. We use an individual's sum of these GCSE points, standardized nationally each year, so that it has mean of 0 and standard deviation

[5] Students attending private schools are not present in the data, but only represent 7% of the student population.

of one.[6] This is for ease of interpretation and to account for any grade inflation that may have occurred during this time period.[7]

We also use alternative measures of student performance to examine the robustness of the results. First, we use a point score, which reflects the differences in the difficulty of attaining certain grades and student performance at Key Stage 3 (at age 14). We also examine whether a student earned a C or higher in at least five GCSEs, including English and math. This is another standard measure of achievement that is widely recognized by the government and employers, and is published in school league tables published by the England's Department of Education.

3.2 Mobile phones use, mobile phone survey and policies

Figure 1 shows the percentage of individuals who owned a mobile phone in England between 2000 and 2012. It shows a steady increase in ownership, reaching 94% in 2012. According to the Office of Communications (Ofcom), teenagers in the UK have similar mobile ownership rates as adults since mid-2000s, with 82% of 12-16 years old in UK owning a mobile phone in 2005 exactly equalling the adult rate (Ofcom, 2006). This masks the differential ownership rates amongst teens, with older teens more likely to own and use mobile phones. There is a large increase occurring between ages 14 and 16. However, ownership rates do not vary considerably by income group among UK teens (Ofcom, 2011).

There is no official policy or recommendation set out by the Department of Education in England regarding mobile phone usage in schools. Therefore, schools' mobile phone policies are decided at the school level by the headteacher and the school's governing body, which has resulted in a large variation in mobile phone policies. As information relating to school policies is not collected centrally, in the spring of 2013 we conducted a survey of high schools in four large cities in England (Birmingham, Leicester, London and Manchester) regarding their mobile phone policies. Before approaching schools, we obtained permission from the relevant Local Authorities.[8] Every secondary school from Local Authorities where permission was granted was

[6] In appendix Table A.6, we additionally provide results according to students' performance on their top eight subjects.

[7] Grade inflation would not affect the final results, as the inclusion of year effects would account for them. However, standardising by year does make the summary statistics easier to interpret.

[8] We did not obtain permission from five Local Authorities in London (Hackney, Lewisham, Newham, Redbridge and Tower Hamlets), which combined have 77 secondary schools. The City of London Authority does not contain any

then contacted. This consisted of two personalized emails, and a follow-up phone call seven days after the second email, had we not yet received a reply. We invited the headteacher or school administrator to complete an online survey, or reply to the questions via email or over the phone.[9]

The survey contained questions about the school's current policy toward mobile phones, when it was implemented, whether there was a previous mobile phone policy and, if so, when it was implemented. This was repeated until we could construct a complete mobile phone policy history at the school since 2000. These questions were supplemented with questions relating to punishments for violating the policy and the headteacher's views on how well the policy was complied with. We also asked if there were any other policy or leadership changes occurring over the same time period, to account for any general shifts in educational policy at the school. [10]

We received completed surveys from 91 schools, which represents 21% of the high schools in the four cities in our sample. This response rate is comparable to other non-governmental survey in academic research such as Card et al (2012), Hall & Krueger (2012), Heffetz (2011) or Brau & Fawcett (2006). Table 1 uses the NPD to illustrate the representativeness of the schools in our sample compared to schools in the cities and to England as a whole, over the entire period. Comparing standardized age 16 test scores, we see that schools in these cities as a whole score approximately the same as the national average, but that the schools in our sample over the whole period achieve significantly higher scores than other schools within these cities (0.06σ). In contrast, the cities have slightly lower age 11 achievement than the national average, and the sampled schools have an even lower intake quality (-0.06σ), although not statically significant at the 10% level. Taken together, this implies that the schools in our sample over the 2001-2011 period have a higher gain in test scores than the average school. Despite this, the sample schools have a significantly more disadvantaged population than other schools in the cities and nationally, enrolling more minority, special educational needs and

public schools and therefore was not approached. The remaining 27 London Local Authorities gave permission, with 337 secondary schools being approached.

[9] The survey questionnaire is presented in the Appendix. Survey website: http://mobilephoneatschool.weebly.com.

[10] This is open to recall bias, but we would expect that headteachers would be very familiar with school-level policies and leadership changes. This is complemented by additional information on policy and leadership changes from each of the schools' websites. Examples of changes are: uniform policy, new buildings, girls allowed in schools and school mergers.

free school meal-eligible pupils. There is no difference in the proportion of male students nationally, between the schools in surveyed cities or in the sample.

Table 2 presents statistics on when mobile phone policies were put into effect and how well they were complied with. There are a multitude of ways in which schools have restricted phone use, from asking for them to be set on silent to not allowing them on school premises. We define a school as introducing a school ban if that school went from no policy to restricting their use on school grounds. Only one school in our sample did not restrict the use of mobile phones between 2001 and 2011. Headteachers were asked to rate to what extent the policy was adhered to by students on a seven-point scale (with 1 meaning "not at all" to 7 meaning "completely"). A school was considered to have a high-compliance ban if the response was greater than four. The table shows that most bans were implemented between 2005 and 2010, and that bans are typically complied with. In Table 3 we provide descriptive statistics for the same characteristics of the surveyed schools pre- and post-ban introduction in comparison to other schools in their cities. The pre-policy averages allow us to compare the representativeness of the surveyed schools before the policies were introduced. We see that the responding schools look very similar to other schools in their cities in terms of their age 16 test scores, SEN, FSM and gender make up. The only considerable difference is that they tend to recruit lower achieving students and have more minority students.

Examining the post-ban characteristics provides the first evidence of any impact the policies may have along with any potential confounding changes in the compositions of the cohorts due to the change in phone policies. Comparing the changes over time, we see that the average age 16 student achievement significantly increases post-policy compared to pre- (0.10σ), but that there is no corresponding significant improvement in the prior performance of the intake students to these schools. This implies that there is minimal sorting by parents according to mobile phone policies or any other changes that occurred in the school. Other permanent student characteristics change slightly pre- and post-ban, with a 5% decrease in the proportion of minority students and a 6% and 7% increase in the proportion of SEN and FSM students, respectively. As these variables are not standardized each year, these differences may reflect general trends in the population. Once the changes over time and the differences across schools are taken into account, there are no significant differences in variables before and after bans are

introduced.[11] Reassuringly these permanent student characteristics are similar for the responding school that never introduced a mobile phone ban. On average students from this school do have higher grades on entry and exit compared to adopting schools. The raw value-added is very similar to the adopting schools pre-policy (0.12σ and 0.13σ respectively) but lower than the schools post adoption (0.20σ). This, combined with the increase in age 16 test scores after ban, could be taken as an early indications of the benefits of restricting mobile phone use in schools.

These comparisons are made using the characteristics of the students that we use for the analysis. However, one may be concerned that the intake of the schools changes once the policy has been introduced which may alter the nature of the schooling environment and hence impact on student test scores. Whilst these potential affects could be interpreted as the total policy impact of a mobile phone ban in a partial equilibrium, with parents sorting between schools with and without bans, the goal of this paper is to estimate the impact of bans in schools that implemented them conditional on student characteristics. To this end, we present series of event studies on the intake of these schools before and after the phone bans conditional on school and year effects in Appendix Figures A.1. The characteristics (gender, FSM, SEN, minority status, age 11 test scores) of students enrolling in their first year of these schools before or after the ban are not significantly different from those enrolling in the year of the ban. There are trends in the type of student not captured by the year effects, but there is no change in the trends with the introduction of the ban. Moreover, the direction of these trends would work against finding an impact of banning policies as the student intakes are increasingly from underperforming groups (increasing rates of FSM, and SEN students and worsening prior test scores).

4. Empirical strategy

We estimate the impact of a mobile phone ban on student achievement, exploiting differences in the timing of the introduction of policies across different schools using a two-way fixed effects model. Equation (1) presents our baseline specification:

$$Y_{ist} = \beta_0 + \beta_1 Ban_{st} + \mu_s + \gamma_t + \varepsilon_{ist} \quad (1)$$

[11] We estimate the effect of these variables on an indicator variable if a policy has been introduced at that school, conditional on year and school effects. Each characteristic is tested separately and none were found to be significantly correlated. See Table A.1 for results; we find no evidence of sorting based on student characteristics.

where Y_{ist} is the test score of student *i* in high school *s* in year *t*. Our primary measure of student performance is test score at age 16.[12] Ban_{st} is the variable of interest and is an indicator variable for whether school *s* prohibits mobile phones from its premises in time period *t*. Accordingly, the coefficient of interest β_1 captures the impact of the introduction of the mobile phone ban on students. This is estimated using the within-school variation in test scores over time. We assume there are three components to the error term that are unobservable; μ is the difference in student performance due to unobservable school effects, γ represents common shocks to all schools in a particular year, and ε is the idiosyncratic error and contains all of the variation in individual outcomes within a school year.

There may be a concern that only high-achieving schools introduce mobile phone bans, which could lead to overestimating the effects of a mobile phone ban. Similarly, if there was a positive trend in student test scores and mobile phone bans were only introduced in the later periods, some of this growth would be incorrectly attributed to bans. We can account for these two possibilities by allowing for school and year mean achievement to vary through fixed effects. The inclusion of these fixed effects allows for the introduction of mobile phone bans to be non-random, i.e. more likely to occur in schools with low or high test scores, as it allows for covariance between Ban_{st} and μ_s as well as γ_t.[13]

Specification (1) is restrictive, as it does not allow for differences in student outcomes other than through ε_{ist}. The individual level panel aspect of the NPD allows us to account for each student's prior performance, which is a large determinant of future achievement. In specification (2), we additionally account for prior student performance, Y_{ist-1}, which is depicted in equation (2). It represents student test scores at age 11. We take this to account for student ability and all school and family investments up until the student starts secondary school. This changes the interpretation of the β_1 parameter from the increase in test scores due to the ban, to the increase in the gains in test scores due to the ban. In addition to prior achievement, we also

[12] We use test score at age 16 as our primary measures of student performance as mobile ownership is higher among older teens. We also estimate impacts on achievement level at age 14 in Table 8. Results using achievement level at age 14 are smaller and insignificant.

[13] Note it does not allow for the effect of the ban to vary across schools or student types. Standard errors are clustered at the school level to account for correlations within school overtime. We also report p-values using percentile-t cluster bootstrap as in Cameron et al (2008) for the main specification.

condition on other observable student characteristics, thereby allowing the growth rate of test scores to vary by each of them. X_i represents the vector of these student characteristics: FSM eligibility, SEN status, gender and ethnicity. The inclusion of these individual controls ostensibly accounts for student sorting to schools on the basis on observable inputs. The extent to which β_1 changes with their inclusion provides us with a gauge for how many students sort to schools based on phone bans.

$$Y_{ist} = \beta_0 + \beta_1 Ban_{st} + \beta_2 Y_{ist-1} + \beta_3 X_{ist} + \mu_s + \gamma_t + \varepsilon_{ist} \quad (2)$$

A final potential threat to identification arises if there are other positive changes to a school that are correlated with the introduction of a mobile phone ban. Up to this point, we have assumed that school effects are invariant over time; if schools introduced other policies that improved test scores at the same time as a phone ban, this again would lead to overestimating the effect of a ban. To address this, we use survey information to control for any leadership or policy changes that occurred during the period of analysis. $OtherPolicy_{st}$ is a dummy variable to control for other leadership or policy changes.[14] In our most demanding specification, we also account for mean peer effects for each student. We know which students were in the same grade as student *i*, and it is possible that students affect each other's growth in test scores through peer effects. Therefore, we additionally condition on the mean prior test scores of all the other students in school *s* in cohort *t*, $\bar{Y}_{-ist-1}$. The inclusion of peer characteristics and information on other policy and leadership changes, as depicted by equation (3), allows us to account for time-variant characteristics of the school.

$$Y_{ist} = \beta_0 + \beta_1 Ban_{st} + \beta_2 Y_{ist-1} + \beta_3 X_{ist} + \beta_4 OtherPolicy_{st} + \beta_5 \bar{Y}_{-ist-1} + \mu_s + \gamma_t + \varepsilon_{ist} \quad (3)$$

Finally, we estimate the heterogeneity of the impact of mobile phone bans by student characteristics in a triple differences framework. β_{1c} is the additional difference in student outcomes by binary student characteristic *c* within schools that implemented a ban in period *t*.

[14] The variable $OtherPolicy_{st}$ takes a value of 1 for the years after a change at a school occurs. We combine information coming from our survey of headteachers and information from school's website. We do not observe multiple change of policies/leader in addition to the phone policy change, hence a binary variable can be used.

We use our most flexible specification (3) above for these estimates and obtain the additional effect of a ban on SEN students, FSM students, males, minorities and by achievement level at age 11.

$$Y_{ist} = \beta_0 + \beta_1 Ban_{st} + \beta_{1c} Ban_{st} * Characteristic_i + \beta_2 Y_{ist-1} + \beta_3 X_{ist} + \beta_4 OtherPolicy_{st} + \beta_5 \bar{Y}_{-ist-1} + \mu_s + \gamma_t + \varepsilon_{ist} \quad (4)$$

5. Results

5.1 Main results

Table 4 presents estimates of the impact of a mobile phone ban on individual student performance. There are five columns, which account for more potential biases as one moves from left to right[15]. Column 1 is the most basic specification that only accounts for the across-school and across-year mean differences in test scores. Here we find a positive relationship between the introduction of a mobile phone ban and student test scores of 5.67 percent of a standard deviation.

However, we still may be concerned that student sorting by observable or unobservable characteristics may be driving this estimate; columns 2 and 3 include student characteristics in order to account for this. Conditioning on prior performance indicates that the growth in test scores is 0.062σ, and this increases to 0.077σ when other student characteristics are also controlled for.

The last two columns account for time-varying school characteristics. Including an indicator variable, which denotes whether there was a leadership change or other policy change at the school has taken place during the period in year *t* or later, increases the estimate slightly. Results of our preferred specification (5), which allows for mean peer effects, are marginally smaller, but continue to show an improvement in student performance after a school bans mobile phones. After a ban has been introduced, the average student attending that school has 7.64% of a standard deviation greater gains in test scores compared to a school that did not introduce a ban.

[15] All coefficients and standard errors in the results tables are multiplied by 100 to ease interpretation.

The third row of Table 4 presents wild cluster Bootstrap P-Values based on 1000 repetitions. For each specification they were within two one hundreds of the clustered standard error, and therefore for the remainder of the tables we only present the clustered standard errors at the school level.

5.2 Heterogeneity

Table 5 studies the heterogeneity of a ban on students with different characteristics, under a triple differences framework, estimating the additional impact on SEN, FSM, male students and by prior test score. This is in addition to any baseline effects of the ban under specification (5). The results indicate that a mobile phone ban has a positive and significant impact on FSM-eligible students (column 1) and SEN students (column 2). The baseline effect of a mobile phone ban is not significant in these specifications, which indicates that results are driven by certain students and that not all students are significantly affected by mobile phone bans. The interaction of the ban with prior achievement is negative (column 4), implying that it is predominantly low-ability students who gain from a ban. The coefficient of -5.27 means that students in the top percentile nationally would lose 0.0527σ with the introduction of a ban compared to a student in the lowest percentile. However, there is a general positive effect of a ban of 0.0745σ, and so overall high-achieving students are not harmed by a ban. This is tested formally in the next table. Column 5 also includes interactions with ability, FSM and SEN simultaneously; we find that the ability and SEN interaction terms are significant. This is in line with the heterogeneity results, with the most at-risk students gaining the most.

Table 6 examines the linearity of the impact of mobile phone bans by prior achievement in more detail. Students are grouped into five quintiles based on their achievement level at age 11, where group 1 has the lowest level of achievement and group 5 has the highest. This time, the coefficients represent the total effect of a ban by ability quintile, as the main effect of the ban is not included. Again we see that low-achieving students gain the most from a ban, and the impact gradually reduces throughout the prior ability distribution. Those in the lowest quintile gain 0.1447σ more after a ban has been introduced. Only the top two quintiles do not

significantly gain from the policy, but they are also not negatively affected.[16] This suggest that students in high prior achievement group at age 11 are able to concentrate in class regardless of the mobile phone policy in place but low-achieving students are distracted by mobile phone use.

One would expect the impact of a mobile phone ban to vary according to how well it was complied with. We replace the single Ban_{st} variable with two variables: one for bans with high compliance, $HighCompliance_{st}$, and one for bans with low compliance, $LowCompliance_{st}$. Table 7 shows the impact of the ban by level of compliance. As expected, we find much larger and significant effects in schools that report a high level of compliance with a ban compared to schools where compliance is weak[17].

As discussed above, mobile phone ownership is higher for older teens and a big increase occurs between age 14 and 16. One would therefore expect the impact of a mobile ban on student test score at age 14 to be smaller. Table 8 replicates Table 4 instead using test score at age 14 as outcome variable. As expected, the coefficient for the impact of the ban are smaller, positive but not significant for the growth in student test scores at age 14.

5.*3* *Placebo and robustness checks*

5.3.1 Event study & Students intake

As a first robustness, we first check for potential trends in student attainment that were present before the introduction of the ban. Figure 2 plots the impact of bans by exposure length. Estimates for negative exposure refer to the years prior to a ban, where we would expect the ban would not have an impact. Using our most preferred specification, we find that bans have significant effects after they have been implemented. There is a general upward trend in the impact of the ban, which reflects that students have experienced more time in a school with a

[16] We reproduced Table 6 by gender: one table for males and one table for females. The results are very similar for both tables, with males and females in low-achieving groups at age 11 gaining the most from a mobile ban.

[17] The compliance measure is coming from our mobile phone survey. Headteachers were asked to rate to what extent the policy was adhered to by students on a seven-point scale (with 1 meaning "not at all" to 7 meaning "completely"). A school was considered to have a high-compliance ban if the response was greater than four. We also created an alternative measure of compliance using punishment at the school after a phone is used. Results were similar and available upon request.

phone ban in place.[18] Moreover, there is little evidence that schools were generally improving before introducing a phone ban, as all the years prior to the ban do not have impacts significantly different from zero and are not increasing.

Table A.1 and Figures A.1 investigate if pupils are sorting to schools based on ban. Table A.1 presents regression estimates for different pupil characteristics (gender, FSM, SEN, Age 11 test score) to investigate whether schools that impose a ban are different and if students are sorting into schools based on student characteristics, conditional on year and school effects. Each pupil characteristic is tested separately and none were found to be significant. Figure A.1 presents school intake before and after ban by pupil characteristics. It shows that pupils are not positively sorting to schools in our sample due to the mobile phone ban in place.

5.3.2 Placebo tests

We next check a key assumption of the model, that we obtain unbiased estimates of β_1 as long as $Cov(\ Ban_{ist},\ \varepsilon_{ist}) = 0$. If schools that introduced a mobile phone ban were improving regardless, then these gains could be falsely attributed to the policy and we would have an upward biased result. We test this by using a placebo treatment, which is generated by turning on the ban dummy two years before it was actually initiated. This placebo intervention should have no significant impact on the gains in student test scores. If there is a positive significant relationship, then there are correlations between the trend and the intervention. Table 9 presents a parallel set of results as Table 4, but with the effects of a placebo intervention in addition to the main treatment (Panel B) and in place of it (Panel A). Panel A is a more demanding specification to reject as the placebo treatment will be taking to account the impact of the actual ban two years later, whereas in Panel B the impact of the actual ban will be captured by β_1. In both cases, the placebo treatments do not produce significant gains in student test scores, and as expected the estimates of the placebo ban are smaller in Panel B than A. Reassuringly the impacts of the actual ban become more significant once other factors are controlled for, whereas the placebo is unchanged. We take this as further evidence that prior trends are not generating these results.

[18] Estimations that directly estimated this additional positive trend failed to find a significant relationship. Given the upward trend found in the treated schools we do not additionally include individual school time trends as this will absorb some of the treatment.

5.3.3 More recent prior ability measures

Thus far we have used age 11 test scores as a measure of prior achievement for student achievement at age 16. However, there is another statutory exam that takes place between these ages. We replicate Table 4 in Table 10 using achievement at age 14 as a measure of ability instead of the age 11 test scores. This has the advantage that it is a more recent measure of student ability, but has the disadvantage that these exams are conducted in secondary school and therefore could also be affected by the ban. To account for this, we only use the age 14 test scores of students attending schools that have not yet implanted a ban. As there is only two years between the age 14 and age 16 exams, this reduces the sample significantly, but also examines the short-run impact of phone bans.[19] The estimates are very similar to our previous estimates. Conditional on age 14 test scores, mobile phone ban improves gains in test scores by 6.83% of a standard deviation. These results again in part address the issue of pre-trends, as we see that there are significantly larger gains in test scores between age 14 and 16 for students who were attending schools that introduced a ban during that time. This is a small window of time for other effects to occur. If a positive trends were in place in schools prior to this, the age 14 tests scores would be higher and gains in test scores would be accordingly lower. The heterogeneity of these results is replicated conditional on age 14 ability. Table A.2 presents similar results to Table 6. The estimates by ability have slightly smaller positive effect for the least able students, but these effects are not significantly different from those in Table 6.

5.3.4 Alternative outcome measures

One may be additionally concerned that these results are dependent on the outcome measure that we are using. Therefore, in the appendix we replicate the previous results using a set of outcome variables to establish the robustness of the estimates. The age 16 measure of achievement used so far in this paper is the standardized point score for all exams taken at the end of compulsory schooling. An alternate scoring system, which accounts for the different difficulties for attaining certain grades, is also used and associated tables can be found in the Appendix (Table A.3). The results and conclusion are once again similar. Tables A.4 and A.5 also replicate the heterogeneity table using the alternative age 16 test score measures, reaching

[19] Specifications that allowed for the impact of the effect to increase over time, to reflect the extended exposure that students would have to the ban, did not find any significant additional effect after a ban is first introduced.

the same conclusion. As some students take more GCSEs that others, thereby allowing for higher total test scores, another measure that is sometimes used is the student's total score in their top eight subjects. Any general increase in exams taken over time will be accounted for by the within year standardisation of test scores. In appendix Table A.6, we provide results according to this measure and results are once again similar. This is not our preferred measure as the number of GCSEs taken could itself be an outcome. This is evidence that the ban is not just related to more exams being taken, but higher test scores achieved.

As noted previously, whether a student scores at least a C on at least five GCSEs, including English and math, is also a recognized measure of achievement used by schools and parents. We derive a binary variable representing whether this standard is met for each student in our sample. This is used as the outcome of interest in the same specifications, and so assumes a linear probability model. In our most demanding specification, we find that a ban improves the probability of a student attaining a C or better on five GCSEs by 2.21 percentage points against a baseline of 38% students in our sample attaining this level (Table A.7). Finally, we present equivalent results at the school level for attaining 5+ GCSEs (Table A.8), which again shows that schools improve after the introduction of a ban.

Overall, results are robust to alternative specifications and to a set of student characteristics, including different measures of prior achievement and peer effects. These numerous robustness checks provide confidence that mobile phone bans play a role in determining school and student performance.

6. Conclusion

This paper investigates the impact of restricting mobile phone use in schools on student productivity. We combine survey data on mobile phone policies in schools in four cities in England with administrative data on student achievement to create a history of student performance in schools. By exploiting differences in implementation dates, our results indicate that there is an improvement in student performance of 7.1% of a standard deviation in schools that have introduced a mobile phone ban.

The existing literature on the impact of technology in the classroom implies that the unstructured presence of technology has ambiguous impacts on student achievement. We add to

this by illustrating that a highly multipurpose technology, such as mobile phones, can have a negative impact on productivity through distraction. Schools that restrict access to mobile phones subsequently experience an improvement in test scores. However, these findings do not discount the possibility that mobile phones could be a useful learning tool if their use is properly structured. Our findings suggest that the presence of mobile phones in schools should not be ignored.

Finally, we find that mobile phone bans have very different effects on different types of students. Banning mobile phones improves outcomes for the low-achieving students (13.77% of a standard deviation) the most and has no significant impact on high achievers. The results suggest that low-achieving students are more likely to be distracted by the presence of mobile phones, while high achievers can focus in the classroom regardless of whether phones are present. Given heterogeneous results, banning mobile phones could be a low-cost way for schools to reduce educational inequality.

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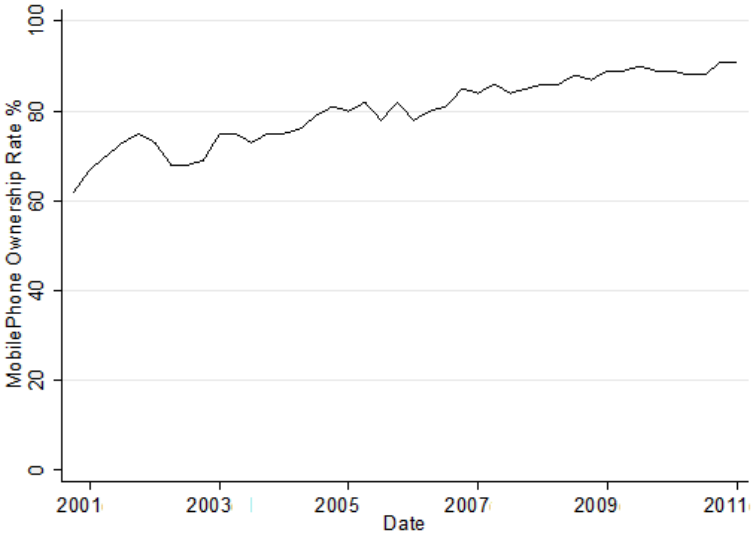
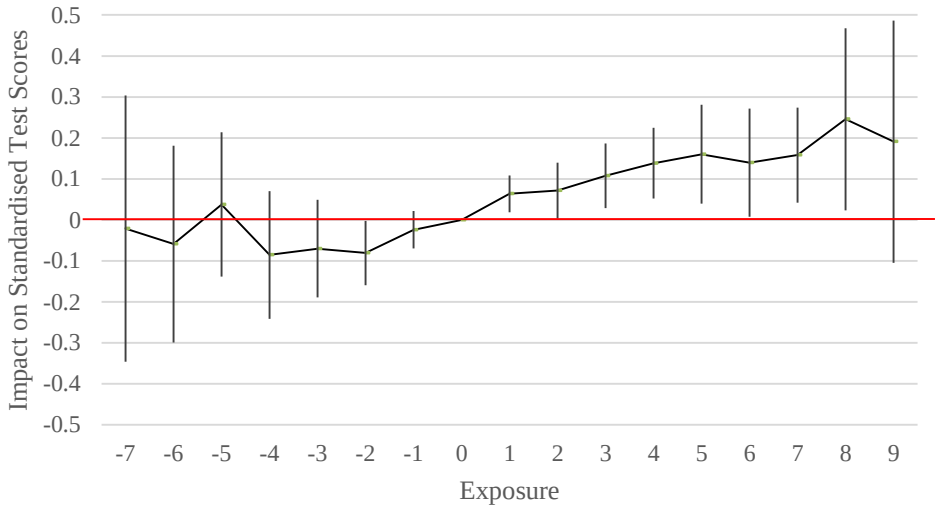
Figure 1: Mobile Phone Ownership Rates in England



Notes: Phone ownership rates in England amongst individuals 13 years and older.
Sources: Oftel/Ofcom, based on face-to-face survey data, 2011

Figure 2: Impact of Phone Ban by Years of Exposure



Notes: Estimated impact on age 16 standardised test scores of mobile phone ban by years of exposure, conditional on school and year effects, age 11 test scores and pupil characteristics. Reference year is the year prior to introduction. Error bars represent the 95% confidence intervals with robust standard errors clustered at the school level. *Sources*: National Pupil Data Base and author-conducted mobile phone policy survey of schools in four cities in England: Birmingham, Leicester, London and Manchester.

Table 1: Descriptive Statistics for Key Variables - Representativeness of Sample

Student Characteristics	All Students in England	Students in Sampled Cities	Students in Responding Schools	Difference Between Responding Schools and Schools in Surveyed Cities
Test scores: Age 16	0.00	0.01	0.07	0.06
	(1.00)	(1.02)	(0.94)	(0.04)
Test scores: Age 11	0.00	-0.03	-0.09	-0.06
	(1.00)	(1.01)	(1.01)	(0.04)
Male	0.51	0.50	0.47	-0.03
	(0.50)	(0.50)	(0.50)	(0.03)
Minority	0.48	0.66	0.74	0.08
	(0.50)	(0.48)	(0.44)	(0.03)
SEN	0.15	0.17	0.18	0.01
	(0.35)	(0.37)	(0.38)	(0.01)
FSM	0.16	0.24	0.31	0.08
	(0.37)	(0.43)	(0.46)	(0.02)
Total students	5,576,276	789,638	130,482	

Notes: Table 2 presents descriptive statistics for key variables for all schools, schools in city surveyed, schools in sample and difference between schools in sample and in city surveyed. SEN means special educational needs students and FSM means Free School Meal students. *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table 2: Descriptive Statistics on Mobile Phone Policies

Year	Mobile Bans	High-compliance Bans	Low-compliance Bans
2000	0	0	0
2001	0	0	0
2002	3	2	1
2003	6	5	1
2004	9	7	2
2005	19	13	6
2006	29	20	9
2007	43	31	12
2008	58	38	20
2009	71	47	24
2010	85	54	31
2011	88	55	33
2012	90	56	34

Notes: Table depicts the number of mobile phone bans in our sample each year. Headteachers were asked what their phone policy is and when it was introduced. A phone ban is classified as 1) A complete ban of mobile phones on school grounds; or 2) Students hand all phones in at the start of school. Headteachers were asked to rate the extent to which the policy is adhered to by students on a seven-point scale with 1 representing "Not at all" and 7 representing "Completely." A school was considered to have a high-compliance ban if the response was greater than four. *Sources:* Author-conducted mobile phone policy survey of schools in four cities in England: Birmingham, Leicester, London and Manchester.

Table 3: Descriptive Statistics on Key Variables Pre- and Post-Policy

Student Characteristics	Students in Sampled Cities	Students in Responding Schools	Pre Phone Ban	Post Phone Ban	Pre-Post Difference	Never Ban Phone
Test scores: Age 16	0.01	0.07	0.02	0.12	0.10	0.14
	(1.02)	(0.94)	(0.96)	(0.92)	(0.04)	(0.93)
Test scores: Age 11	-0.03	-0.09	-0.11	-0.08	0.03	0.02
	(1.01)	(1.01)	(1.01)	(1.01)	(0.04)	(0.95)
Male	0.50	0.47	0.47	0.47	-0.00	0.53
	(0.50)	(0.50)	(0.50)	(0.50)	(0.02)	(0.50)
Minority	0.66	0.74	0.77	0.72	-0.05	0.79
	(0.48)	(0.44)	(0.42)	(0.45)	(0.03)	(0.41)
SEN	0.17	0.18	0.15	0.21	0.06	0.20
	(0.37)	(0.38)	(0.36)	(0.40)	(0.01)	(0.40)
FSM	0.24	0.31	0.28	0.35	0.07	0.25
	(0.43)	(0.46)	(0.45)	(0.48)	(0.02)	(0.43)
Total students	789,638	130,482	62,214	66,266		2002

Notes: Table 3 presents descriptive statistics for key variables pre- and post-policy and for all schools and schools in the city surveyed. SEN means special educational needs students and FSM means Free School Meal students. *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table 4: Effect of Mobile Bans on Student Performance

Age 16 Test Scores	(1)	(2)	(3)	(4)	(5)
Mobile ban	5.67	6.19*	7.76**	7.92**	7.64*
	(3.13)	(2.95)	(3.78)	(3.85)	(3.90)
Wild Cluster Bootstrap P-Values	*0.128*	*0.072*	*0.039*	*0.040*	*0.053*
Prior test scores: Age 11		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Prior peer achievement					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table 4 presents regression estimates for student performance. The outcome variable is the standardized test score at age 16. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means special educational needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1. *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table 5: The Effect of Mobile Phone Bans on Student Performance by Student Characteristics

Age 16 Test Scores	(1)	(2)	(3)	(4)	(5)
Mobile ban	6.03	5.97	5.47	7.45*	5.63
	(4.03)	(4.11)	(4.14)	(3.90)	(4.23)
Mobile ban * FSM	5.66*				3.20
	(3.02)				(2.88)
Mobile ban * SEN		10.00***			5.62*
		(3.27)			(3.33)
Mobile ban * Male			4.71		
			(3.95)		
Mobile ban * Prior test scores: Age 11				-5.27***	-4.22***
				(1.32)	(1.32)
Prior test scores: Age 11	✓	✓	✓	✓	✓
Student characteristics	✓	✓	✓	✓	✓
Other policy changes	✓	✓	✓	✓	✓
Prior peer achievement	✓	✓	✓	✓	✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table 5 presents regression estimates for student performance. The outcome variable is the standardized test score in a student's eight best subjects. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for using indicators for whether the student was male, a minority, SEN and FSM. SEN means special educational needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1. *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table 6: The Effect of Mobile Phone Bans on Student Performance by Prior performance

Age 16 Test Scores	(1)	(2)	(3)	(4)
Impact by age 11 test scores				
Mobile ban * 1st Quintile	13.06***	14.45***	14.68***	14.47***
	(3.89)	(4.22)	(4.28)	(4.30)
Mobile ban * 2nd Quintile	8.68**	10.58***	10.80***	10.60***
	(3.85)	(3.95)	(4.13)	(4.16)
Mobile ban * 3rd Quintile	5.66	7.67**	7.85*	7.62*
	(3.89)	(3.44)	(4.10)	(4.17)
Mobile ban * 4th Quintile	2.75	4.03	4.18	3.87
	(3.99)	(4.02)	(4.09)	(4.16)
Mobile ban * 5th Quintile	-1.18	0.18	0.26	-0.11
	(4.12)	(4.38)	(6.13)	(4.46)
Test scores: Age 11 categorical	✓	✓	✓	✓
Student characteristics		✓	✓	✓
Other policy changes			✓	✓
Prior peer achievement				✓
School effects	✓	✓	✓	✓
Year effects	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482

Notes: Table 6 presents regression estimates for student performance. The outcome variable is the standardized test score in a student GCSE exams. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. Key Stage 2 represents standardized test scores at age 11. In this table, student are divided into quintiles based on their achievement level at age 11, where group 1 is the lowest-achieving group and group 5 is the highest-achieving group. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1. *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table 7: The Effect of Mobile Phone Bans on Student Performance by Ban Compliance

Age 16 Test Scores	(1)	(2)	(3)	(4)	(5)
High Compliance mobile ban	6.19*	6.68**	8.35**	8.53**	8.28**
	(4.02)	(4.03)	(4.18)	(4.26)	(4.26)
Low Compliance mobile ban	1.59	2.33	3.12	3.17	2.60
	(11.09)	(10.58)	(10.63)	(10.67)	(10.96)
Prior test scores: Age 11		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Prior peer achievement					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table 7 presents regression estimates for student performance. It separates bans into high-compliance (principal assessment score above 4 out of 7) and low-compliance mobile bans. The outcome variable is the standardized test score at age 16. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table 8: Effect of Mobile Bans on Student Performance at Age 14

Age 14 Test Scores	(1)	(2)	(3)	(4)	(5)
Mobile ban	0.80	1.59	2.47	2.70	2.60
	(2.23)	(2.11)	(2.06)	(2.06)	(2.00)
Prior test scores: Age 11		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Prior peer achievement					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	112,212	112,212	112,212	112,212	112,212

Notes: Table 8 presents regression estimates for student performance at age 14. The outcome variable is the standardized test score at age 14. All estimates and standard errors are multiplied by 100 to ease interpretation. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for based on whether the student is a male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil database (NPD) and author-conducted mobile phone survey.

Table 9: Effect of Placebo Mobile Bans on Student Performance

Age 16 Test Scores	(1)	(2)	(3)	(4)	(5)
Panel A: Placebo Only					
Placebo mobile ban	2.88	2.96	3.08	3.34	3.24
	(5.25)	(5.03)	(5.07)	(5.06)	(5.02)
Panel B: Placebo and Actual Ban					
Placebo mobile ban	2.44	2.48	2.48	2.77	2.69
	(5.17)	(4.93)	(4.98)	(4.97)	(5.07)
Mobile ban	5.49	6.01*	7.58**	7.72**	7.46*
	(3.53)	(3.46)	(3.76)	(3.75)	(3.80)
Prior test scores: Age 11		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Prior peer achievement					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table 9 presents regression estimates for student performance. A placebo ban is introducing the ban two years before it was actually introduced. The outcome variable is the standardized test score at age 16. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1. *Sources*: National Pupil Database (NPD) and author-conducted mobile phone survey.

Table 10: Effect of Mobile Bans on Student Performance Conditioning on Age 14 Test Scores

Age 16 Test Scores	(1)	(2)	(3)	(4)	(5)
Mobile ban	6.55*	5.35*	6.94**	6.94**	6.83*
	(3.76)	(3.33)	(3.39)	(3.42)	(3.46)
Prior test scores: Age 14		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Peer characteristics					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	83,211	83,211	83,211	83,211	83,211

Notes: Table 10 presents regression estimates for student performance. The outcome variable is the standardized test score at age 16 and control for standardized test score at age 14. Estimated on the sample of students who had not been exposed to the ban when examined at age 14. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Appendix A

Mobile Phone Survey Questionnaire

Question 1.1) What best describes the school's current mobile phone policy?

a) Complete ban of mobile phones on school grounds

b) Allowed on grounds, but must be turned off

c) Allowed on grounds, but must be turned to silent and off during classes

d) Allowed on grounds, but must be turned to silent at all times

e) Allowed on grounds, but must be considerate with use

f) Other

g) None

Question 1.2) If Other, could you please briefly describe current policy.

Note: Only Answer: Hand into reception, and collected at end of day.

Question 1.3) When was the current policy first introduced?

Question 1.4) What are the punishments for misuse of phones on school grounds?

Question 1.5) Out of 7, to what extent would you say the policy is adhered to by students? [With 7 being "Completely" and 1 being "Not at all"]

Question 2) Was there a different policy in place before this? - Yes/No

If Yes, please answer the following.

If No, please skip to question 4.

In the space below, please answer questions 1.2 to 1.5 for this pervious policy (brief description of policy/introduction date/punishments/adherence).

Question 3) Was there a different policy in place before this? - Yes/No

If Yes, please answer the following.

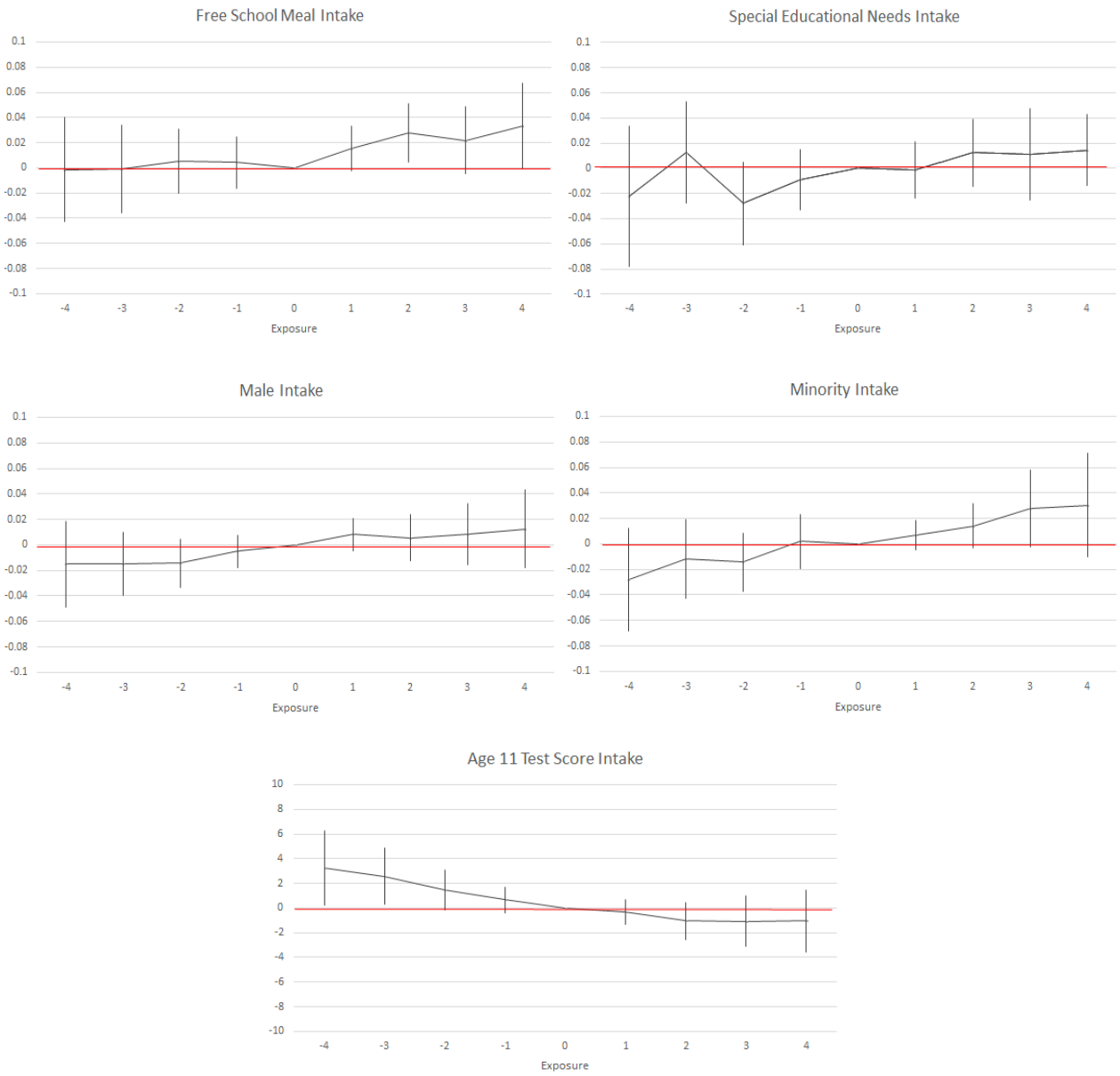
If No, please skip to Question 4.

In the space below, please answer questions 1.2 to 1.5 for this previous policy (brief description of policy/introduction date/punishments/adherence).

Question 4) Were there any other policy or leadership changes at the same time as the mobile policy change?

Question 5) Do you have any other comments?

Figures A.1



Notes: Estimated impact of mobile phone ban on school intake at age 11, by pupil characteristics conditional on year and school effects. Reference year is the year prior to introduction. Error bars represent the 95% confidence intervals with robust standard errors clustered at the school level. *Sources*: National Pupil Data Base and author-conducted mobile phone policy survey of schools in four cities in England: Birmingham, Leicester, London and Manchester.

Table A.1: Balancing Test

Variables	Age 11 Student Performance	Male	Minority	SEN	FSM
Mobile ban	-0.074	-0.39	0.01	0.81	1.07
	(1.25)	(0.44)	(0.72)	(1.00)	(0.70)
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table A.1 presents regression estimates for different outcome variables to investigate whether schools that impose a ban are different and if students are sorting into schools based on student characteristics. SEN means the proportion of students that are Special Educational Needs students and FSM means the proportion of students that are Free School Meal students. Male and Minority are the proportion of students that are male or from a minority group, respectively. We use robust clustered standard errors at the school level with school and year fixed effects. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table A.2: Effect of Mobile Bans on Student Performance by Prior Achievement Group Age 14

Age 16 Test Scores	(1)	(2)	(3)	(4)
Impact by age 14 test scores				
Mobile ban * 1st Quintile	10.15***	11.26***	9.64***	9.51**
	(3.53)	(3.63)	(3.64)	(3.69)
Mobile ban * 2nd Quintile	9.35***	11.19***	9.64**	9.50**
	(3.60)	(3.65)	(3.76)	(3.78)
Mobile ban * 3rd Quintile	5.51	6.95*	5.21	5.06
	(3.80)	(3.80)	(3.99)	(4.05)
Mobile ban * 4th Quintile	2.13	3.77	1.91	1.77
	(3.90)	(3.86)	(4.11)	(4.16)
Mobile ban * 5th Quintile	-0.72	1.92	0.57	0.43
	(4.40)	(4.77)	(4.65)	(4.67)
Test scores: Age 14 categorical	✓	✓	✓	✓
Student characteristics		✓	✓	✓
Other policy changes			✓	✓
Peer characteristics				✓
School effects	✓	✓	✓	✓
Year effects	✓	✓	✓	✓
Observations	83,211	83,211	83,211	83,211

Notes: Table A.2 presents regression estimates for student performance. The outcome variable is the standardized test score. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. In this table, students are grouped into five categories based on their achievement level at age 14, where group 1 is the lowest-achieving group and group 5 is the highest-achieving group. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table A.3: Effect of Mobile Bans on Student Performance

Age 16 Alternate Test Scores	(1)	(2)	(3)	(4)	(5)
Mobile ban	5.32	5.88*	7.39**	7.49**	7.22**
	(3.35)	(3.28)	(3.51)	(3.56)	(3.60)
Prior test scores: Age 11		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Peer characteristics					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table A.3 presents regression estimates for student performance. The outcome variable is the standardized test score at age 16. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for based on whether the student is male, a minority, SEN and FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table A.4: Effect of Mobile Bans on Student Performance by Student Characteristics

Age 16 Alternate Test Scores	(1)	(2)	(3)	(4)	(5)
Mobile ban	5.80	6.03	5.43	7.05*	6.19*
	(3.70)	(3.79)	(3.84)	(3.60)	(3.69)
Mobile ban * FSM	4.99*				3.07
	(2.73)				(2.61)
Mobile ban * SEN		7.14**			
		(3.03)			
Mobile ban * Male			3.88		
			(3.65)		
Mobile ban * Prior test scores: Age 11				-4.54***	-4.26***
				(1.27)	(1.23)
Prior test scores: Age 11	✓	✓	✓	✓	✓
Student characteristics	✓	✓	✓	✓	✓
Other policy changes	✓	✓	✓	✓	✓
Peer characteristics	✓	✓	✓	✓	✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table A.4 presents regression estimates for student performance. The outcome variable is the alternate test scores at age 16 which accounts for different difficulty for attaining certain grades. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table A.5: Effect of Mobile Bans on Student Performance by Prior Achievement Quintile: Age 11

Age 16 Alternative Test Scores	(1)	(2)	(3)	(4)
Impact by age 11 test scores				
Mobile ban * 1st quintile	10.80***	12.13***	12.27***	12.07***
	(3.60)	(3.95)	(3.99)	(4.00)
Mobile ban * 2nd quintile	9.10**	10.91***	11.05***	10.85***
	(3.53)	(3.76)	(3.83)	(3.84)
Mobile ban * 3rd quintile	5.93	7.86**	7.97**	7.75*
	(3.65)	(3.79)	(3.85)	(3.91)
Mobile ban * 4th quintile	2.67	3.93	4.02	3.73
	(3.70)	(3.76)	(3.80)	(3.86)
Mobile ban * 5th quintile	-1.110.78	0.28	0.32	-0.03
	(3.81)	(4.11)	(4.15)	(4.18)
Test scores: Age 11 categorical	✓	✓	✓	✓
Student characteristics		✓	✓	✓
Other policy changes			✓	✓
Peer characteristics				✓
School effects	✓	✓	✓	✓
Year effects	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482

Notes: Table A.5 presents regression estimates for student performance. The outcome variable is the alternate test scores at age 16 which accounts for different difficulty for attaining certain grades. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. In this table, students are grouped in five categories based on their achievement level at age 11, where group 1 is the lowest-achieving group and group 5 is the highest-achieving group. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1. *Sources:* National Pupil database (NPD) and author-conducted mobile phone survey.

Table A.6: Effect of Mobile Bans on Student Performance – Top 8 subjects

Age 16 Test Scores – Top 8 subjects	(1)	(2)	(3)	(4)	(5)
Mobile ban	3.96*	4.47**	6.03**	6.06**	5.93**
	(2.26)	(2.22)	(2.37)	(2.41)	(2.43)
Prior test scores: Age 11		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Prior peer achievement					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table A.6 presents regression estimates for student performance. The outcome variable is the standardized test score at age 16 on top 8 subjects. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means special educational needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1. *Sources:* National Pupil Database (NPD) and author-conducted mobile phone survey.

Table A.7: Effect of Mobile Bans on Probability of Achieving 5 GCSEs Including English and Math

Age 16 Alternate Test Scores	(1)	(2)	(3)	(4)	(5)
Mobile ban	1.90*	2.14**	2.71***	2.58***	2.21**
	(0.98)	(0.96)	(0.96)	(0.96)	(0.92)
Prior test scores: Age 11		✓	✓	✓	✓
Student characteristics			✓	✓	✓
Other policy changes				✓	✓
Peer characteristics					✓
School effects	✓	✓	✓	✓	✓
Year effects	✓	✓	✓	✓	✓
Observations	130,482	130,482	130,482	130,482	130,482

Notes: Table A.7 presents regression estimates for student performance. The outcome variable is the passing GCSE - EM. We use robust clustered standard errors at the school level with school and year fixed effects. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1
Sources: National Pupil database (NPD) and author-conducted mobile phone survey.

Table A.8: Effect of Mobile Bans on School Performance

School Performance: % of Students Achieving 5 Cs, including English & math	(1)	(2)	(3)	(4)
Mobile ban	1.88*	2.08**	2.04**	2.07**
	(1.06)	(1.04)	(0.96)	(0.98)
Prior test scores: Age 11		✓	✓	✓
Mean student characteristics			✓	✓
Other policy changes				✓
School effects	✓	✓	✓	✓
Year effects	✓	✓	✓	✓
Schools	90	90	90	90
Observations	816	816	816	816

Notes: Table A.8 presents regression estimates for proportion of student who pass five GCSEs including English and Maths examinations. We use robust clustered standard error at the school evel. Student characteristics are controlled for whether a student is male, a minority, SEN or FSM. SEN means Special Educational Needs students and FSM means Free School Meal students. The "Other policy changes" variable controls for whether there was a leadership or policy changes occurring at the time of the introduction of a mobile phone ban. *** p<0.01, ** p<0.05, * p<0.1 *Sources:* National Pupil database (NPD) and author-conducted mobile phone survey.