THE EFFECT OF SCHOOL STARTING AGE ON SPECIAL NEEDS INCIDENCE AND CHILD DEVELOPMENT INTO ADOLESCENCE*

Simone Balestra, Beatrix Eugster, Helge Liebert

CDI, University of St. Gallen

Abstract

Children starting school at older ages consistently exhibit better educational outcomes. In this paper, we underscore child development as a mechanism driving this effect. We study the causal effect of school starting age on a child's probability of developing special educational needs in early grades. We find that starting school at a relatively older age decreases the probability of developing special needs by approximately 6 percentage points. This decrease is due to a lower incidence of various behavioral and learning impairments. Importantly, the effect is not driven by non-expert over-referrals of relatively younger children to special needs services. The effect is persistent throughout compulsory schooling, resulting in higher test scores in grade eight. Although these performance differentials are significant, they do not affect labor market entry.

JEL classification: I14, I21, J13
Keywords: school starting age, special needs, child development

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1 Introduction

Virtually all education systems have a single cutoff date that determines when children become eligible for compulsory schooling. This cutoff rule creates a continuum of ages at school entry, whereby the oldest child is up to one year older than his or her youngest classmates. Research has shown that children who are relatively older at school entry achieve better educational outcomes (Black, Devereux, and Salvanes, 2011; Fredriksson and Öckert, 2013). Although this pattern is consistent across countries (Bedard and Dhuey, 2006), the underlying mechanism that supports this empirical regularity remains unclear.

One prominent explanation from developmental psychology is maturity (Whitebread, 2012). While children are ready to learn at all ages, young children are usually less prepared to engage in academic work than their older peers (Morrison, Alberts, and Griffith, 1997; Stipek and Ryan, 1997) and more vulnerable to external influences (Datar and Gottfried, 2015). This developmental disadvantage might trigger special educational needs in children, e.g., due to increased incidence of learning impairments or behavioral problems. Following ICD-10 diagnosis guidelines, we define special needs as an umbrella term for special educational requirements resulting from learning disabilities, communication disorders, emotional and behavioral disorders, physical disabilities, and developmental disabilities.

Children who develop special needs during childhood have a higher risk of subsequent history of unsuccessful education, difficulties in labor market integration, and lower earnings during adulthood (Hanushek, Kain, and Rivkin, 2002; Wagner and Blackorby, 1996). In addition, educating children with special needs is considerably more costly than educating children without special needs (Duncombe and Yinger, 2005). It is thus imperative for policy makers to understand the scope of school starting age (SSA) on child development, with respect to not only achievement but also to special needs demand.

In this paper, we study the causal effect of SSA on a child's probability of developing special educational needs in early grades. We then assess the persistence of SSA effects at the end of compulsory schooling and labor market entry in late adolescence. We are able to credibly identify the effects of SSA through a regression discontinuity design based on the exact day of birth. In Switzerland, children are supposed to enter compulsory school in the fall if they have reached age four before August 1 of the same year. This institutional rule allows us to compare children born around the cutoff, children who are observationally similar but who enter school at different ages. Prior research shows some evidence that increases in SSA reduce children's risk of disability classification (Dhuey and Lipscomb, 2010; Elder, 2010) and improve measures of mental health (Dee and Sievertsen, 2014; Mühlenweg, Blomeyer, Stichnoth, and Laucht, 2012). We contribute to this literature along three dimensions.

First, we present novel evidence on the relationship between SSA and special needs incidence. We base our analyses on a unique data source that allows us to study various aspects of the development of special needs due to SSA. The data contain the population of children, born from 1993 to 2002, who enrolled in eighth grade in the Swiss canton of St. Gallen.[1] We merge the school data with administrative records from the School Psychological Service (SPS). The SPS is a canton-wide, centralized service that provides children and their families with counseling and diagnosis for school-related problems. For each child, we observe whether the child has ever been to the SPS, when the SPS first registered the child, when and how often the child visited the SPS, and whether the SPS dismissed the child. Furthermore, for those children who were sent to the SPS, we have detailed

[1]Switzerland is a federal republic comprising 26 member states called cantons. St. Gallen is the fifth largest canton in Switzerland with a population of about 500,000.

information on the reason, caseworkers' assessment, and experts' diagnoses. Our data thus constitute a major improvement on existing data sets, which are primarily retrospective non-expert surveys.

Second, the data allow us to perform a comprehensive assessment of the effects of SSA within a uniform institutional framework. While our main outcomes are special needs incidence, type, and severity, we also consider both medium- and long-run effects. In the medium run, we examine the effect of SSA on grade repetition and test scores at the end of compulsory education. In St. Gallen, each eighth grade student has to take a standardized test in Math, German, and English. Moving further towards long-run persistence, we pose the question of whether SSA effects still matter at the age of labor market entry. We thus merge our data with administrative records on vocational education and training (VET) and post-compulsory secondary education required for higher education. In Switzerland, roughly 70% of each cohort chooses the VET track after compulsory schooling, directly entering the labor market. About 20% of students continue on the academic track and enter higher education. We consider two outcomes: whether a student enters VET and whether a student enters the academic track.

Third, we shed light on the interplay between experts' evaluation and educators' behavior towards special education classification. Dhuey and Lipscomb (2010) and Schwandt and Wuppermann (2016) show that, in some cases, educators use special needs classification as a supplemental service that targets additional resources at younger students. In the presence of this over-referring, experts' evaluations of special needs become crucial. When specialists—as compared to teachers or parents—perform the diagnoses, the risk of applying relative standards is much smaller (Dalsgaard, Knoth Humlum, Skyt Nielsen, and Simonsen, 2012). We deal with this issue by distinguishing between the decision to refer a child for special needs evaluation (made by non-experts such as teachers or parents) and the results of an expert evaluation, which is made by SPS psychologists. In addition, we also observe *when* an evaluation takes place, in order to distinguish the special needs that emerge after school entry from those that are diagnosed before school start.

The results indicate that children entering school at a younger age have a higher risk of developing special needs than children starting school one year later. Being born on July 31 instead of August 1 increases the probability of developing special needs by 6 percentage points or about 20%. Importantly, this effect is entirely driven by special needs developed after kindergarten, not due to pre-existing health conditions. We also show that the effect does not simply stem from younger children's being over-referred for special needs evaluation. By distinguishing by type of special needs, we find that entering school at a younger age mostly increases behavioral problems and learning impairments and, to a lesser extent, the incidence of dyslexia/dyscalculia, speech impediments, and ADHD (Attention Deficit Hyperactivity Disorder). At the intensive margin, we find that younger children on average have nearly one more consultation with the SPS than older children.

At the end of compulsory education, differences in SSA still affect students' school outcomes. We find that younger students perform worse on standardized tests and that younger students are more likely to repeat a grade by the end of compulsory education than their older peers. However, these medium-run differences disappear in the long run, when adolescents choose their post-compulsory education track. Children starting school younger are as likely to find an apprenticeship position as children entering school later. Similarly, children with lower SSA are also equally likely to enter the academic track as their peers with higher SSA.

In sum, we find that a lower SSA triggers the development of special needs upon school entry and that this age effect persists until the end of compulsory education. However, we find no significant long-term effect at labor market entry or higher academic education. Our results thus suggest that the negative effects of going to school at a younger age are limited within the domain of compulsory education and do not affect post-compulsory education outcomes.

The remainder of this study proceeds as follows. Section 2 gives an overview of the data and the institutional background. Section 3 introduces and explains our empirical strategy. Section 4 presents and discusses the results, and performs a series of robustness checks. Section 5 relates our findings to the existing literature and Section 6 concludes.

2 Data and institutional background

In St. Gallen, children enter compulsory schooling in the fall if they have reached age four before August 1 of the same year. The typical school curriculum consists of two years of kindergarten, six years of primary school, and three years of secondary school. Ability tracking occurs after primary school, with children entering either a higher-ranked (*Sekundarschule*) or a lower-ranked (*Realschule*) track of secondary school. After finishing secondary school, children typically enter either high school or vocational education.

Mainstreaming is a common practice in Swiss schools.[2] However, about 2% of children—those who have severe physical or mental handicaps that would not allow them to follow a regular curriculum—are educated in special education institutions. We do not have any information about these children in our data. The regular public schools, however, offer institutionalized support services for children who develop special educational needs. Special educational needs result from diagnosed impairments associated with behavioral problems or learning dif-

[2]In Switzerland, 95% of schools are public.

ficulties, e.g., ADHD, dyslexia/dyscalculia, or speech impediments. In such cases, the teacher notifies both the parents and the School Psychological Service.[3] The SPS then initiates contacts with the family and schedules an assessment meeting. During this meeting, the SPS staff performs a diagnostic evaluation, provides a diagnosis, and recommends therapy if necessary. After the assessment session, the SPS keeps track of the child's progress and is the liaison between involved parties.

Our analysis focuses on the student population of the canton of St. Gallen. We combine data for all students enrolled in eighth grade from 2008 through 2017 with data on special needs from the SPS of the canton of St. Gallen. We observe for the entire population of enrolled students the exact date of birth, gender, an indicator of whether they are native German speakers, and the test results on a compulsory standardized test on Math, German, and English.

For every child who has ever been in contact with the SPS, we observe the age at and reason for registration (e.g., learning difficulties, disruptive behavior, family problems), the number of consultations, and comprehensive information on the diagnoses and the suggested treatments. This data set allows us to construct measures of the onset and severity of special needs. Furthermore, we can distinguish between non-expert and expert assessment by comparing the teacher- or parents-initiated registration at the SPS with the SPS staff assessment and, if necessary, a further diagnosis.

The achievement data are based on a compulsory standardized test taken in eighth grade, called "Stellwerk8." Stellwerk8 is a norm-referenced, self-scoring, adaptive, computer-based exam similar in spirit to the Graduate Record Examination. All students in grade eight—except those enrolled in special education schools—are tested. The test is administered between February and April, towards the end of the school year. The test results are important for students. After the

[3]The SPS is organized at the cantonal level and operates through its eight regional offices, one for each school district.

test, students receive a certificate with their Stellwerk8 results. This certificate is usually provided to potential employers when students apply for apprenticeship positions during ninth grade (the last year of compulsory education).

In addition to the data on school performance, we add data about the children's career path after compulsory education. Upon finishing compulsory schooling, most Swiss children typically enter Vocational Education and Training (VET) by applying for VET positions and signing a training contract with a firm. VET combines part-time formal education with training and experience at the workplace.[4] We link our data to information about all VET contracts signed in the canton of St. Gallen in 2008-2016. A smaller percentage of each cohort enters the academic preparation track ("high school") to obtain a higher education entrance qualification. We link the children in our data to the administrative high school records to track those who enter the academic track after compulsory schooling. For the analysis, we lose the last cohort of the data because of poor match overlap in the VET and high school data, due to children not yet having left school.

Table 1 shows the descriptive statistics of our sample. About 30% of children are referred to special needs services at some point during their school career. However, 7.9% are dismissed without a diagnosis after the initial screening and do not receive further support. The remaining 22.5% are diagnosed with special educational needs and receive follow-up measures. The 22.5% prevalence match the proportion reported in aggregate statistics at the federal level and are also in line with figures reported from other OECD countries (OECD, 2008). For about 80% of children with special needs, the first onset occurs within three years after entering school.

[4]Students who attend a VET program study part-time at school for 1 to 1.5 weekdays. For the remaining time (3.5 to 4 weekdays), students work as apprentices in host companies with whom they have an employment contract for their entire three- to four-year training period. See Oswald and Backes-Gellner (2014) for an overview of the Swiss VET system. For a broader perspective on VET across countries, see Wolter and Ryan (2011).

Table 1: Descriptive statistics

	(1) Median	(2) Mean	(3) SD	(4) N
A1. Special needs: Incidence, onset, severity				
Special needs (SN)	0.000	0.305	0.460	50,110
SN: onset before primary school	0.000	0.059	0.236	50,110
SN: onset during primary school	0.000	0.245	0.430	50,110
SN: dismissed after initial examination	0.000	0.079	0.270	50,110
SN: positive diagnosis	0.000	0.225	0.418	50,110
Consultations	0.000	2.864	6.723	50,110
A2. Special needs: Heterogeneity				
Behavioral problems	0.000	0.094	0.291	50,110
Learning impairments	0.000	0.264	0.441	50,110
ADHD	0.000	0.046	0.209	50,110
Dyslexia/dyscalculia	0.000	0.186	0.389	50,110
Speech impediment	0.000	0.129	0.336	50,110
Domestic violence	0.000	0.023	0.149	50,110
B1. School performance, 8th grade				
Test score: Math (standardized)	−0.007	0.000	1.000	41,600
Test score: German (standardized)	0.035	0.000	1.000	41,604
Test score: English (standardized)	0.029	0.000	1.000	40,994
Grade repetition by 8th grade	0.000	0.063	0.243	41,825
B2. Labor market entry				
Vocational education	1.000	0.631	0.483	41,825
Academic preparation track	0.000	0.179	0.383	41,825
C. Covariates				
Female	0.000	0.489	0.500	50,110
Non-native speaker	0.000	0.154	0.361	50,110
Born after July 31	0.000	0.417	0.493	50,110
Age at test	14.950	15.004	0.622	50,110
Age at SPS registration	8.740	8.926	2.361	15,270

Note: Descriptive statistics for the main estimation sample. Source: Data from the School Psychological Service St. Gallen, Lehrmittelverlag St. Gallen, and (vocational) education administration St. Gallen.

3 Empirical strategy

In the canton of St. Gallen, a child enters kindergarten in August if he or she is four years old before August 1 of the same year. This cutoff date causes some children to be older than others when they enter compulsory school. We adopt a regression discontinuity (RD) design around the August 1 cutoff to study the effect of school starting age on the development of special needs in early childhood.

Let X_i denote the forcing variable and $\bar{x}$ the known cutoff date, normalized to $\bar{x} = 0$. In our case, X_i represents the (exact) date of birth and $\bar{x}$ is the cutoff date

August 1. The cutoff date determines whether child i enters compulsory school in the relevant year ($X_i < 0$) or not ($X_i \geq 0$). Finally, let $Y_i(1)$ and $Y_i(0)$ denote the potential outcomes of the children entering compulsory school in the relevant year or not, respectively. The parameter of interest is the average treatment effect at the cutoff τ_{RD}:

$$\tau_{\text{RD}} = \text{E}\,[\; Y_i(1) - Y_i(0) \mid X_i = \bar{x} \;] \;. \tag{1}$$

Under a testable continuity assumption, Hahn, Todd, and Van der Klaauw (2001) show that τ_{RD} is nonparametrically identifiable as the difference of two conditional expectations evaluated at the cutoff $\bar{x} = 0$:

$$\begin{aligned} \tau_{\text{RD}} &= \mu^{+} - \mu^{-} = \lim_{x \to 0^{+}} \mu(x) - \lim_{x \to 0^{-}} \mu(x) \;, \\ \mu(x) &= \text{E}\,[\; Y_i \mid X_i = x \;] \end{aligned} \tag{2}$$

The objective is to estimate a flexible approximation near the cutoff of the regression functions $\mu^{-}(x) = \text{E}\,[\; Y_i(0) \mid X_i = \bar{x} \;]$ and $\mu^{+}(x) = \text{E}\,[\; Y_i(1) \mid X_i = \bar{x} \;]$. To do so, we approximate the regression functions above and below the cutoff by means of local linear regressions, with weights computed by applying a kernel function on the distance of each observation's score to the cutoff. This nonparamentric local polynomial approach has become the standard choice for estimation of RD treatment effects (Gelman and Imbens, 2017).

In implementing the RD approach, we need to choose the kernel function for weighting the observations and the bandwidth for determining the sample size around the cutoff. The choice of the kernel function makes little difference in practice. For our main specifications, we rely on a triangular kernel, which is better suited for estimating a function at boundary points than the epanechnikov kernel (Cheng, Fan, and Marron, 1997).

For the choice of bandwidth, we follow a recent approach developed in Calonico, Cattaneo, and Titiunik (2014) and Calonico, Cattaneo, Farrell, and Titiunik (2016). They show that commonly used bandwidth selectors tend to yield bandwidths that are too large to ensure the validity of the underlying distributional approximations, potentially leading to non-negligible bias. They propose an alternative method, with the RD point estimate corrected by an estimated bias term; the standard error estimates are then adjusted for the additional variability resulting from the estimation of the bias correction term. Throughout the paper, we present the bias-corrected estimates, and we select the bandwidth such that the point estimator for the bias-corrected estimate is mean square error optimal (see Calonico et al., 2016). We also test the sensitivity of our results to different bandwidth choices. The methods used for generating graphical results always correspond to those used for the estimation (with the exception of controlling for birth cohort in the estimations).

Although predetermined individual characteristics are not required for identification, their inclusion may improve precision. Identification is valid if the conditional expectation functions of the covariates are continuous at the cutoff (Calonico et al., 2016). In some regressions, we include child gender, an indicator for non-native speaker, birth-year cohort fixed effects, postal code, or test year fixed effects. However, including covariates does not change the results qualitatively, and in our main specification we only include birth-year cohort fixed effects.

As outlined above, identification in the RD design relies on the idea of local randomization around the threshold. We present some evidence for the validity of the identifying assumption. One main concern is that individuals manipulate the running variable by systematically timing birth in consideration of the school starting threshold. Manipulation typically leads to asymmetric sample selection and sorting on either side of the cutoff, which is often indicated by bunching in the distribution on one side of the assignment threshold. Figure A1 shows the distribution of date of birth in our sample. There is no visible drop in births before August 1. More formally, using the test outlined in McCrary (2008), we cannot reject the null hypothesis of a zero discontinuity at the threshold (p-value = 0.34).

In addition, if observations are locally randomized at the threshold, any predetermined characteristics should be balanced at the threshold. Panels (a) and (b) in Figure A2 show discontinuity graphs for the probability of being female and the probability of being a non-native speaker, respectively. Both characteristics are balanced at the threshold. To alleviate residual concerns about the covariate balance, we present regression results with and without controlling for gender, non-native speaker, and birth cohort fixed effects as a robustness check. The evidence presented in Figures A1 and A2 supports the internal validity of the RD design.

4 Results

4.1 Graphical evidence

In this section, we present graphical evidence on the incidence of special educational needs among children starting school at relatively younger ages. Panel (a) in Figure 1 shows the probability of developing special needs by date of birth, relative to the school starting threshold of August 1. A child is classified as having special needs if he or she came into contact with the SPS before or during school time. On average, 30% of all children are in contact with the SPS at least once. The graph in Panel (a) shows that this fraction is about 28% for children born on or after August 1. In contrast, children born on July 31 or earlier have a 4 percentage points higher probability of developing special needs.

This result could be driven by several mechanisms. The main explanation

Figure 1: Special needs: Incidence and onset

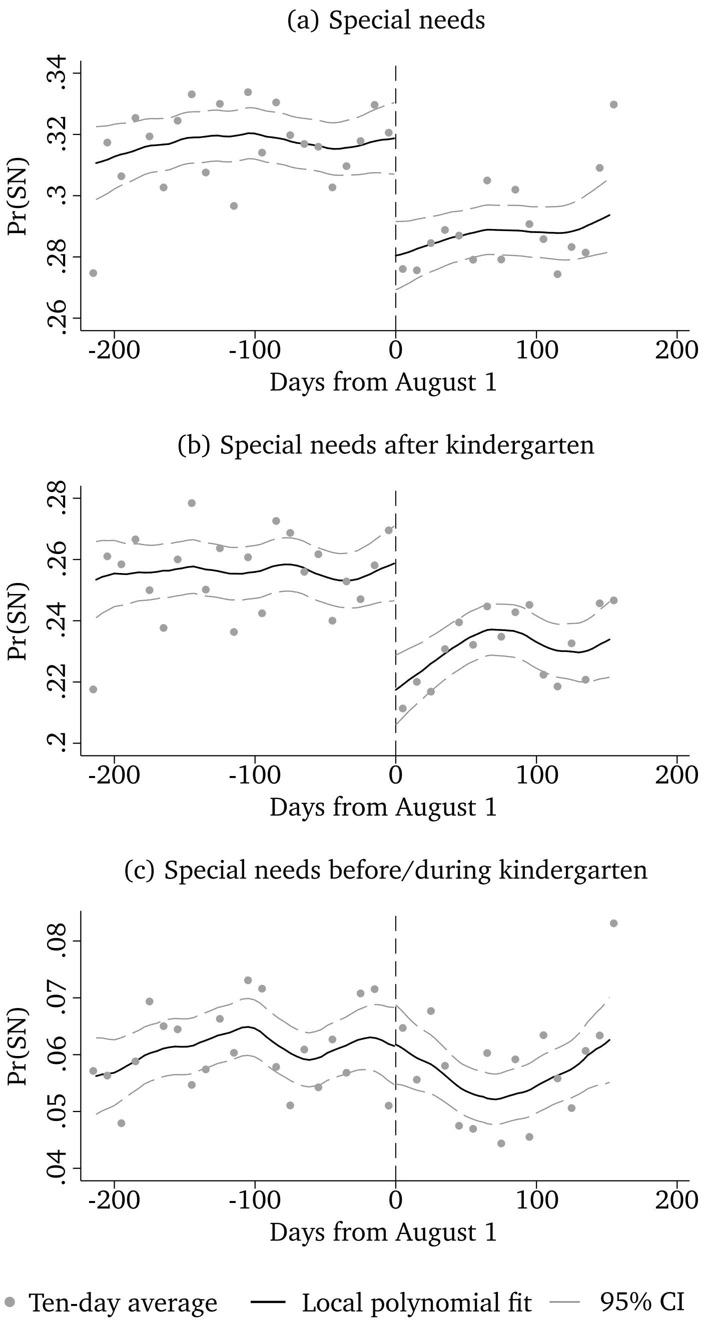
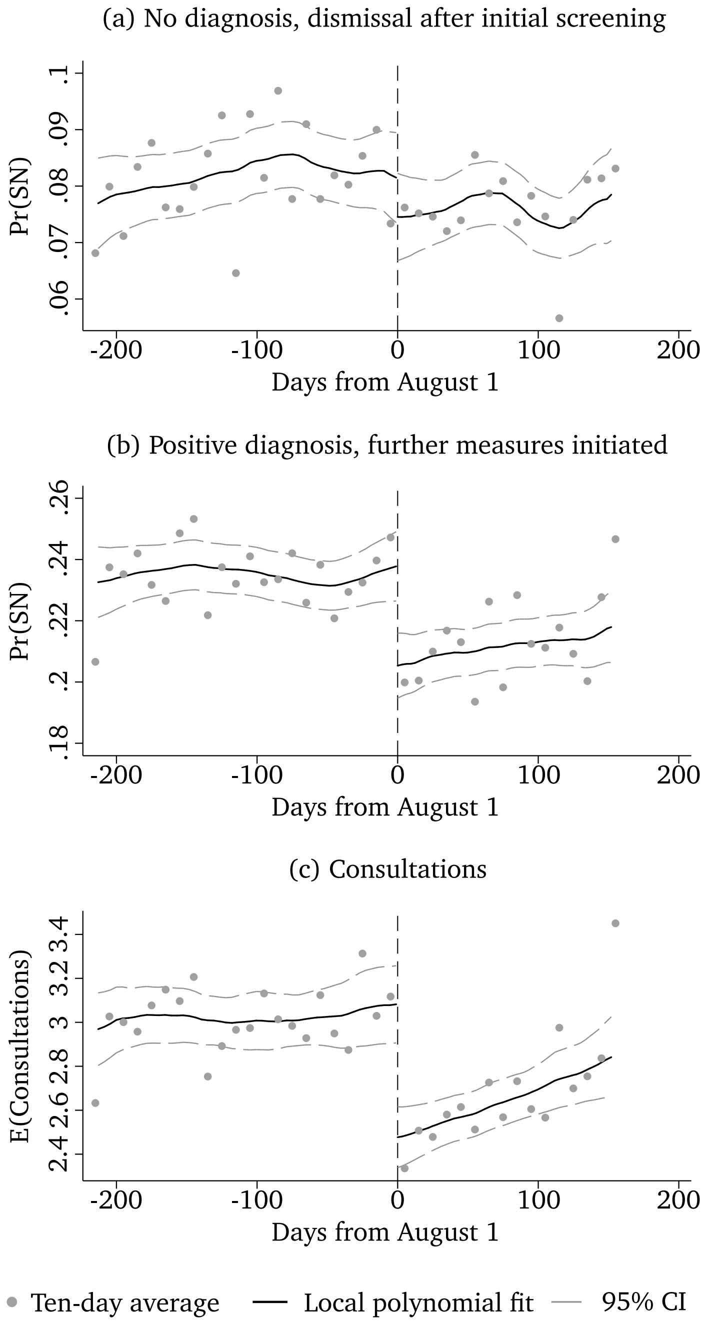


Figure 2: Special needs: Severity



Note: Discontinuity graphs plotting ten-day averages and cutoff-dependent local linear regression estimates of school starting age on measures of special needs incidence, onset, and severity. Local linear regression results are based on triangular kernel weights and a bandwidth choice following Calonico et al. (2016). Confidence limits (95%) are plotted in gray. Source: Data from the School Psychological Service St. Gallen, Lehrmittelverlag St. Gallen, and (vocational) education administration St. Gallen.

is that children develop special needs when subjected to the pressure of grading and peer performance in primary school. However, as in many other school systems, the possibility of redshirting a child, i.e., delaying school entry for a year, exists in Switzerland. Typically, because redshirting occurs before the child enters kindergarten, parents requesting redshirting would send their child to the SPS for examination. If the SPS found significant delays in that child's development, it would approve the parental request. Therefore, the higher proportion of special needs among children born at or before July 31 could be driven by parents wishing to delay the school entry of their children.

However, only about 6% of cases at the SPS were referred by their parents. To differentiate between special needs developed during school and registrations influenced by the parents of the children, Panels (b) and (c) of Figure 1 stratify the incidence of special needs by the time of onset. We compare the incidence of special needs occurring after entering primary school (b) to the incidence before or during kindergarten (c). Interestingly, the main effect at the cutoff is completely driven by special needs occurring during primary school, with no discontinuity in SPS registration before or during kindergarten. This result suggests that redshirting is not a main driver of special needs incidence on the left side of the cutoff.

In Figure 2, we investigate whether the effect is driven by purely superficial increases in screening or by actual changes in true special needs diagnoses. This mechanism would be possible if teachers and parents were inclined to refer children for special needs evaluation because of their younger age rather than because of any actual need for special education. We distinguish between cases which are initially registered with the SPS but diagnosed negatively (Panel a) and cases with positive diagnoses requiring further treatment (Panel b). While there may be a slightly higher rate of registered cases without a diagnosis at a younger age, we find that most of the effect is driven by cases diagnosed positively and receiving

Table 2: School starting age and special needs incidence

(A) SPECIAL NEEDS: INCIDENCE, ONSET AND SEVERITY

	SN	SN, onset before school	SN, onset during school	No diagnosis, dismissal	Positive diagnosis, further measures	Nr. of consultations
τ_{RD}	−0.059***	0.014	−0.070***	0.002	−0.058***	−0.779***
	(0.018)	(0.011)	(0.019)	(0.012)	(0.018)	(0.258)
MSE-min. bw.	60	44	47	41	49	57
$\bar{Y}_{-\text{bw}}$	0.32	0.06	0.26	0.08	0.24	3.16
$\bar{Y}_{+\text{bw}}$	0.28	0.06	0.22	0.08	0.20	2.44
$N_{-\text{bw}}$	8227	6194	6589	5597	6863	7854
$N_{+\text{bw}}$	8575	6286	6705	5694	7020	8130
N	50110	50110	50110	50110	50110	50110

(B) SPECIAL NEEDS: DIAGNOSIS

	Behavioral problems	Learning impairments	ADHD	Dyslexia/ dyscalculia	Speech impediments	Domestic violence
τ_{RD}	−0.040***	−0.054***	−0.025***	−0.036**	−0.033**	0.001
	(0.014)	(0.018)	(0.009)	(0.015)	(0.016)	(0.007)
MSE-min. bw.	42	55	50	58	39	42
$\bar{Y}_{-\text{bw}}$	0.10	0.27	0.05	0.19	0.13	0.03
$\bar{Y}_{+\text{bw}}$	0.09	0.24	0.04	0.16	0.11	0.02
$N_{-\text{bw}}$	5721	7550	6995	8109	5333	5889
$N_{+\text{bw}}$	5831	7806	7166	8413	5392	5971
N	50110	50110	50110	50110	50110	50110

Note: Estimates for τ_{RD} corespond to the treatment effect derived in section 3. All models include birth cohort specific effects. Heteroskedasticity-robust standard errors reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

further treatment. In addition, we find a large discontinuity in the number of consultations received (Panel c). Children born just before August 1 and entering school early require about 0.6 consultations more than children from the same cohort entering school one year later.

4.2 Special needs

In this section we present the reduced form estimation results of the effect of school starting age on the development of special needs. Table 2 shows the estimated threshold effects using local linear regressions. We control in all regressions for year-of-birth fixed effects. Observations are weighted using a triangular kernel, and the bandwidth is symmetric around the threshold and chosen by minimizing the regression discontinuity mean squared error.

Panel (a) in Table 2 presents the point estimates corresponding to the graphs in the previous section. Being born on August 1 instead of July 31 decreases the probability of developing special needs by 5.9 percentage points, a finding corresponding approximately to an 18% reduction. This large effect is entirely driven by special needs developed after kindergarten, when children are in a more competitive school environment. We also find that the effect is not simply driven by younger children being over-referred for screening. Instead, we find that younger children are also diagnosed positively and receive treatment at higher rates, leading to 0.78 more consultations on average.

Panel (b) shows the results for common types of special needs. We find that entering school at an older age decreases behavioral problems by 4% and learning impairments by about 5%. We also find a negative effect for the incidence of ADHD, dyslexia/dyscalculia, and speech impediments. While partly determined by genetic inheritance, these types of special needs can also be influenced and triggered by external factors, such as peer environment at school (Elder, 2010; Mühlenweg et al., 2012). In contrast, we do not find any effect on outcomes determined outside of school or unrelated to SSA such as domestic violence.

4.3 Medium- and long-term outcomes

Early differences in the development of special needs can lead to persistent differences in achievement. However, children registered with the SPS typically receive support, and they may also repeat a grade if the gap in achievement is too large for them to bridge. Educational achievement differences between younger and older children may thus fade away over time (Crawford, Dearden, and Greaves, 2014).

In Table 3, we test whether differences still persist at the age when children finish school and enter the labor market as young adults. To remove possible grading effects, the regressions control additionally for the year of the test. We

Table 3: School starting age and long-term outcomes

	Educational achievement in grade 8				Labor market entry	
	Standardized test score			Grade	Vocational	Academic
	Math	German	English	repetition	education	preparation
τ_{RD}	0.082*	0.131***	0.115***	−0.039***	0.025	−0.021
	(0.050)	(0.047)	(0.044)	(0.009)	(0.030)	(0.023)
MSE-min. bw.	46	47	55	69	28	30
$\bar{Y}_{-\text{bw}}$	538.94	523.83	558.56	0.07	0.64	0.18
$\bar{Y}_{+\text{bw}}$	543.82	528.81	562.83	0.04	0.62	0.19
$N_{-\text{bw}}$	5345	5348	6153	7842	3111	3344
$N_{+\text{bw}}$	5350	5353	6245	7972	3109	3349
N	41600	41604	40994	41825	41825	41825

Note: Descriptive statistics for the main estimation sample. Source: Data from the School Psychological Service St. Gallen, Lehrmittelverlag St. Gallen, and (vocational) education administration St. Gallen.

also discard the last year of data for the long-term outcomes, due to poor match overlap.

The first set of outcomes focuses on educational achievement in eighth grade, towards the end of compulsory schooling (age 15). Looking at the test results of a standardized high-stakes exam given at the end of eighth grade, we find that children born on August 1 or after still consistently outperform younger students. Their test scores in Math, German, and English are on average about 0.1 standard deviations better than those of children born on July 31 or before. We also find that older children are 4% less likely to have repeated a grade during their school career.

We then analyze whether these differences have a lasting impact on labor market entry and life transitions for young adults. We do not find that achievement differences persist into difference in success at transition. Children entering school early are just as likely to enter VET by signing a training contract as children entering school later. Similarly, younger children are also equally likely to enter the academic preparation track.

4.4 Sensitivity and robustness checks

We perform a series of robustness checks to demonstrate that our results are stable and not driven by a spurious correlation in the data. First, we perform a variety of specification checks using our main outcome, special needs incidence. In Table A1, we perform the analysis without covariates (column 1), then add birth cohort fixed effects (our main specification, column 2), individual covariates (3) and postal code fixed effects (4). We change the inference to clustering at the running variable (5), use an asymmetric optimal bandwidth selection (6), and change the kernel used for weighting (7). None of these modifications change the size or significance of our main estimate.

Second, we perform a set of placebo tests. In Table A2, we assume a placebo cutoff in the middle of the distribution of the running variable both left (Panel a) and right (Panel b) of the original cutoff. We repeat the analysis for all outcomes used in Table 2. Two estimates out of 24 are significant at 10%, that is, no more than we should expect by chance.

Third, we verify that our results are not driven by a specific bandwidth choice. Although such concerns are mitigated by our relying on algorithm-based bandwidth selections, we test the stability of our estimates and the bias-variance trade-off inherent to bandwidth choice by repeating our analysis for a large set of outcomes and bandwidths. Results are plotted in Figure A3. The graphs indicate no particular pattern deviating from our main results.

5 Discussion

This paper adds to a growing literature on the impact of SSA on diverse outcomes over the life-cycle. Most of the existing studies can be divided into three groups, based on their main outcomes. The first group studies the effect of SSA on the development of special needs conditions, with most attention given to ADHD and hyperactivity. The second group investigates educational and cognitive achievements, and the third group looks at mid- to long-term outcomes including earnings, mental health, and crime.

The first group of papers finds that a higher SSA leads to decreases in the probability of receiving special education services (Dhuey and Lipscomb, 2010) and in the incidence of symptoms of inattention and hyperactivity (Dee and Sievertsen, 2014; Elder, 2010; Mühlenweg et al., 2012). We complement the findings of these papers by showing that the effect on special education needs is driven by onset after school enrollment and not due to pre-existing conditions. Moreover, we find that diagnoses such as behavioral problems, learning impairments, ADHD, dyslexia/dyscalculia, and speech impediments are also affected by SSA.

Dalsgaard et al. (2012) discuss the role of specialist behavior in the effect of SSA on the incidence of ADHD. They suggest that the effect of SSA on ADHD is driven by non-specialist diagnoses or over-referral of young children to special education services. Our results indicate that the effect persists even when specialists are performing the diagnosis.

Results from the second group of papers indicate that a higher SSA increases test scores in grades three through eight. This finding is not only consistent across different institutional settings (Bedard and Dhuey, 2006; Dhuey, Figlio, Karbownik, and Roth, 2017; McEwan and Shapiro, 2008) but also comparable to our estimates in terms of sign and magnitude. Similarly, McEwan and Shapiro (2008) and Dhuey et al. (2017) also report compensatory behavior towards younger children such as redshirting and grade repetition.

The main concern with research about the SSA effect on test scores is age at test. As Crawford, Dearden, and Greaves (2014) argue, a large portion of the SSA effect on test scores is driven by age at test. Given that we have data on a standardized test administered towards the end of grade eight, we cannot distinguish between SSA effects and age-at-test effects (beyond controlling for year of birth). However, this caveat does only apply to test scores and not to any other outcome under our investigation.

Finally, the studies on long-term impacts of SSA find negligible effects on IQ scores, mental health at age 18, and earnings (Black, Devereux, and Salvanes, 2011); but some significant effects on criminal behavior at young ages (Landerso, Skyt Nielsen, and Simonsen, 2017). Similar to these studies, our results show no significant effects on medium- to long-run outcomes such as the probability of entering VET or academic preparation.

In summary, our paper connects and complements the above-mentioned strands of literature, by investigating different outcomes and mechanism from childhood through late adolescence. In that sense, most closely related to our work is Fredriksson and Öckert (2013), who study the effects of SSA on educational attainment and earnings over the life-cycle. They find strong effects for test scores but no effects for earnings. We add to this study by shedding light on the mechanisms through which these effects operate, i.e., the incidence of special educational needs and diagnoses upon compulsory school entry.

6 Conclusions

The results of this paper suggest that starting school at a relatively younger age can be an important factor in the onset of special needs during the early years of primary school. At the extensive margin, younger children are more likely to be diagnosed with special needs. At the intensive margin, they receive more frequent examinations and counseling by the school psychologists. Although younger children are more likely to repeat a grade and children with special needs receive therapies and support, they still score lower than their older peers in standardized tests at the end of compulsory schooling. However, the age differences at school start do not translate into differences in outcomes at labor market entry. Both younger and older school starters are equally likely to start vocational education or academic preparation. Thus educational achievement differences do not appear to jeopardize the transition after compulsory schooling.

Taking this result into account, we maintain that educational differences due to SSA matter and need consideration in their own right. Most school systems are characterized by a universal date threshold that determines school start. Two measures may mitigate the vulnerability of relatively young children who are born just before the cutoff date. First, the possibility of postponing school entry by a year should be granted to children who exhibit developmental delays. Although the practice of redshirting already occurs, it is currently initiated exclusively by the parents. Given that parents of high socio-economic status are more likely to redshirt, this practice creates disadvantages for younger children in families from a lower socio-economic background (Bassok and Reardon, 2013). Instead, redshirting should be subject to an institutionalized process and external evaluation.

Second, children at risk should be assessed by medical and psychological experts for school readiness. To efficiently identify those children at risk, one possibility would be improving information sharing between preschool and kindergarten educators. Currently, such information sharing practice is not institutionalized in Switzerland.

As we cannot differentiate between relative and absolute school starting age, investigating whether a general increase in school starting age would lead to a reduction in special needs conditions is outside the scope of this paper. Resolving this issue—possibly by means of a reform of school starting age—would be a valuable complement to our results and should thus be the focus of future research.

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Appendix: Tables and Figures

Table A1: Specification checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
τ_{RD}	-0.058^{***}	-0.059^{***}	-0.058^{***}	-0.058^{***}	-0.059^{***}	-0.059^{***}	-0.062^{***}
	(0.019)	(0.018)	(0.018)	(0.018)	(0.019)	(0.017)	(0.019)
Cohort FE		✓	✓	✓	✓	✓	✓
Indiv. covariates			✓	✓			
Postcode FE				✓			
Kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Epanechnikov
Inference method	HC0	HC0	HC0	HC0	Cluster	HC0	HC0
BW selection	Symmetric	Symmetric	Symmetric	Symmetric	Symmetric	Asymmetric	Symmetric
bw_-	58	60	59	59	53	72	51
bw_+	58	60	59	59	53	60	51
$\bar{Y}_{-\text{bw}_-}$	0.32	0.32	0.32	0.32	0.32	0.32	0.32
$\bar{Y}_{+\text{bw}_+}$	0.28	0.28	0.28	0.28	0.28	0.28	0.28
$N_{-\text{bw}_-}$	7985	8227	8109	8109	7417	9895	7126
$N_{+\text{bw}_+}$	8268	8575	8413	8413	7643	8736	7337
N	50110	50110	50110	50110	50110	50110	50110

Note: Estimates for τ_{RD} corespond to the treatment effect derived in section 3. Model specification and covariates as indicated. Standard errors reported in parentheses. Inference method as indicated in the table. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Table A2: Placebo checks

(A) PLACEBO: DAYS BEFORE AUGUST 1, ARTIFICIAL CUTOFF DATE ON APRIL 17

	ONSET AND SEVERITY						DIAGNOSIS					
	SN	SN, onset before school	SN, onset during school	No diagnosis, dismissal	Positive diagnosis, further measures	Nr. of consultations	Behavioral problems	Learning impairments	ADHD	Dyslexia/ dyscalculia	Speech impediments	Domestic violence
τ_{RD}	0.036	0.011	0.024	0.011	0.026	0.318	0.026	0.028	0.017	0.020	−0.019	0.009
	(0.026)	(0.014)	(0.022)	(0.014)	(0.023)	(0.343)	(0.016)	(0.022)	(0.012)	(0.021)	(0.018)	(0.009)
MSE-min. bw.	32	34	36	41	33	45	30	39	23	33	33	28
$\bar{Y}_{-\text{bw}}$	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
$\bar{Y}_{+\text{bw}}$	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
$N_{-\text{bw}}$	4255	4551	4855	5654	4411	6228	4118	5251	3015	4551	4551	3844
$N_{+\text{bw}}$	4593	4874	5117	5886	4738	6415	4468	5501	3344	4874	4874	4205
N	29203	29203	29203	29203	29203	29203	29203	29203	29203	29203	29203	29203

(B) PLACEBO: DAYS AFTER AUGUST 1, ARTIFICIAL CUTOFF DATE ON OCTOBER 17

	ONSET AND SEVERITY						DIAGNOSIS					
	SN	SN, onset before school	SN, onset during school	No diagnosis, dismissal	Positive diagnosis, further measures	Nr. of consultations	Behavioral problems	Learning impairments	ADHD	Dyslexia/ dyscalculia	Speech impediments	Domestic violence
τ_{RD}	0.016	0.024*	−0.010	−0.006	0.050*	0.021	−0.006	0.035	−0.011	0.013	−0.003	0.004
	(0.030)	(0.013)	(0.029)	(0.014)	(0.028)	(0.342)	(0.021)	(0.030)	(0.014)	(0.027)	(0.020)	(0.010)
MSE-min. bw.	21	23	21	30	18	29	18	20	18	19	21	23
$\bar{Y}_{-\text{bw}}$	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
$\bar{Y}_{+\text{bw}}$	0.07	0.07	0.07	0.08	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07
$N_{-\text{bw}}$	3021	3340	2872	4253	2414	4122	2559	2872	2559	2697	3021	3340
$N_{+\text{bw}}$	2863	3125	2744	3942	2369	3803	2489	2744	2489	2596	2863	3125
N	20907	20907	20907	20907	20907	20907	20907	20907	20907	20907	20907	20907

Note: Estimates for τ_{RD} corespond to the treatment effect derived in section 3. Sample selection based on all data before (Panel a) or after (Panel b) the original August 1 cutoff. Models assume a placebo cutoff at the respective mid-sample date. All models include birth cohort specific effects. Heteroskedasticity-robust standard errors reported in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.

Figure A1: Distribution of birth dates

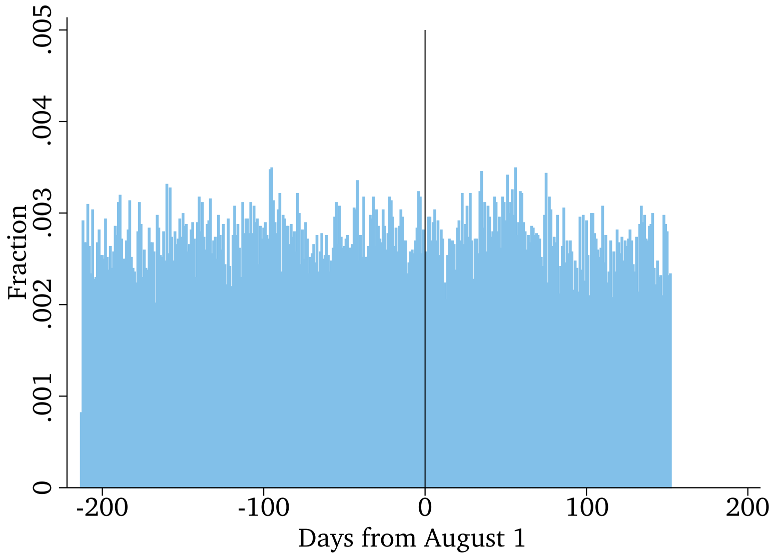

Figure A2: Covariate balance

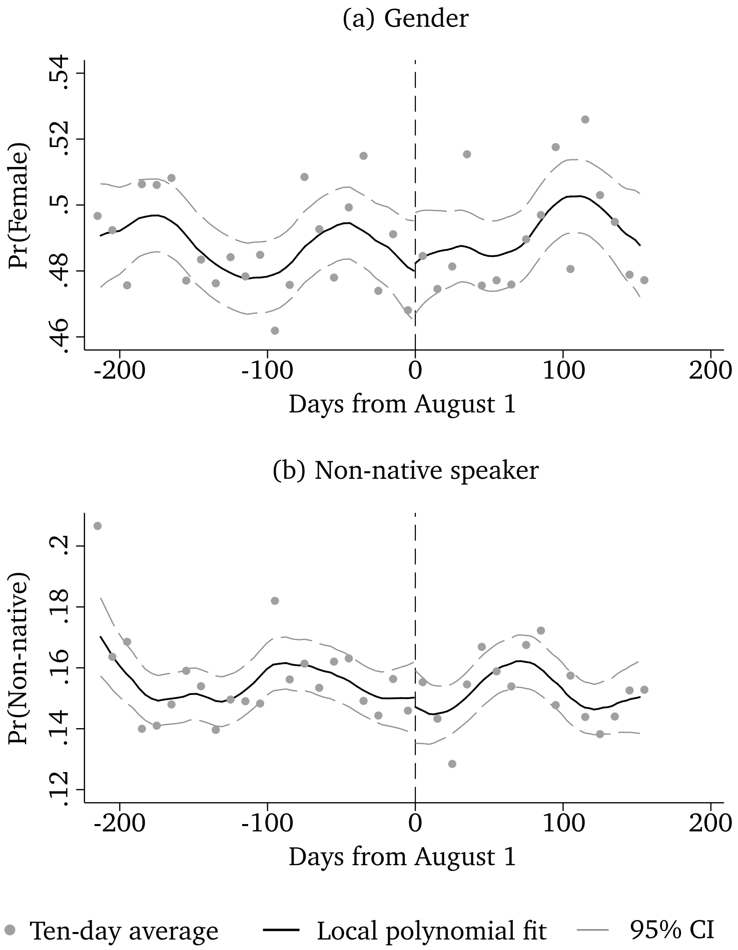

Figure A3: Bandwidth variations