

THE LONG-TERM EFFECTS OF EARLY TRACK CHOICE*

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We investigate the effects of attending a more advanced track in middle school on long-term education and labour market outcomes for Germany, a country with a rigorous early-age tracking system, where the risk of misallocating students is particularly high. Our research design exploits quasi-random shifts between tracks induced by date of birth, and speaks to the long-term effects of early track attendance for a group of marginal students most at risk of misallocation. Remarkably, we find no evidence that attending a more advanced track leads to more favourable long-term outcomes. We attribute this result to the possibility of later track-reversal.

Countries differ widely with respect to the way they organise their school systems. While Germany and Singapore deliberately track students into different schools based on ability as early as the end of elementary school (ages 10/12), other countries, such as the US, the UK and Japan, essentially keep their entire secondary education system comprehensive. Proponents of tracking systems stress that allocating students to learning environments more adequate for their abilities can lead to more efficient educational production, whereas opponents argue that tracking may exacerbate initial disadvantages. Most particularly, they point to the danger that small differences between students in innate ability or social background before tracking may translate into large differences in adult outcomes through exposure to very different learning environments. This problem is particularly acute in a system that tracks students very early on, when information about the student's learning potential is likely to be incomplete and track allocation is, at least to some extent, determined by sheer luck. But initial mistracking need not lead to life-long disadvantage, as long as the tracking system has built-in flexibilities that allow correction of initial choices at a later point, and when more information about individuals' abilities is available. This important aspect in assessing tracking systems has hardly been discussed in the literature so far.

Thus, to assess whether early track allocation has indeed life-long consequences, and whether a tracking system successfully allows for correcting initial misallocations, requires a comparison of long-term educational and labour market outcomes of individuals who were at the margin between two tracks and who were randomly allocated into a higher or a lower track. It is such a natural experiment on which we draw in this article. We explore this for Germany, a country with a particularly rigorous tracking system that very early on (at age 10) allocates students into three different school tracks based on ability and locks them into the assigned track throughout middle school (i.e. from grades 5 to 9). These tracks are designed to support particular career paths: the high track prepares students for college or university education, while the medium and low tracks aim at providing skills for white and blue collar

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apprenticeships. As a result, the three tracks differ widely, especially in terms of teaching curricula as well as peer and teacher quality.

Our research design exploits quasi-random shifts between tracks induced by date of birth. Based on this design, discussed in detail in subsection 2.1, we can identify (a lower bound of) the causal effect of track exposure for students who are at the margin between two tracks (hereafter, marginal students). These are students whose parents or teachers may be unsure of which track the student should attend after elementary school and who are therefore most at risk of misallocation. We first show that children who are born after the age of school entry cut-off date are more likely to attend a more advanced track in middle school than children who are born before the age of school entry cut-off date and who are thus younger in class. This is the first stage of our analysis. We then investigate the impact of date of birth on long-term labour market outcomes and educational attainment, obtaining reduced form estimates. Despite the differences in learning environments between tracks and a strong first stage, we find that date of birth has no effect on wages, employment or occupation choice at later ages. This suggests that, for students at the margin between two tracks, attending a more advanced track in middle school bears little benefits later in life.

What explains this surprising finding? We attribute it to the up and downgrading of students between tracks that takes place at a later stage of their educational career: we first show a substantial amount of movement from the low or medium to the high track at the end of middle school (age 15/16), an upgrading facilitated by the school system. We further demonstrate a substantial amount of downgrading at the age of 18/19 through non-enrollment in college or university after graduating from the high track. Due to this up and downgrading, attending a more advanced track induced by birth date has, for marginal students, hardly any impact on the probability of graduating from a medium or high track, completing an apprenticeship, or graduating from college or university. These findings of zero effects on long-term outcomes for marginal students do not imply that there is no difference in observed outcomes of students who sort into different tracks in middle school: our own calculations based on the German Socio-Economic Panel show that these differences are large, reflecting the ability-based selection that characterises a tracking system.¹

These findings emphasise a core aspect of the basis on which tracking systems should be assessed: the built-in possibilities for correcting earlier allocations at a stage when more information is revealed about a student's true potential. That is, although the young age at which the tracking decision is taken creates particularly large risks for student misallocation, the system we study also allows students whose potential has been erroneously assessed to revise the initial track decision at later stages in their educational careers. Our findings underscore that these built-in flexibilities allow marginal students to fully make up for the exposure to a less challenging school environment during middle school – even if the exposure to a less challenging school environment is prolonged (in our case 5–6 years) and the differences in school environments are large.

¹ OLS regressions based on the GSOEP suggest that completing the medium *versus* the low track is associated with a 16% wage differential, whereas completing the high *versus* the medium track is associated with a 23% wage differential.

The article is structured as follows: Section 1 provides an overview of the relevant literature and the German tracking system. Sections 2 and 3 then outline our empirical research design and data sources, respectively. Section 4 reports the empirical results and Section 5 presents our discussion and conclusions. Besides reporting additional results in online Appendix B, we also provide a theoretical model of track choice which formalises the shifting of students to a different track because of birth month and clarifies how the key differences between school tracks (i.e. teaching technology and peer quality) may affect long-term outcomes.

1. Background

1.1. Existing Literature

The literature on tracking has adopted three approaches to assess the effects of tracking on student outcomes, relying on across-country, within-country and within-school variation. Exploiting variation in school systems across countries, Hanushek and Wössmann (2006) show that the variance of the test score distribution increases between elementary and middle school in countries with a tracked school system relative to countries with a comprehensive school system, without an increase in the mean. They thus conclude that tracking increases achievement of high ability students at the expense of low ability students. Waldinger (2007) argues that these findings are sensitive to the way countries are categorised into a tracked or comprehensive school system.

A number of recent papers evaluate policy reforms which effectively reduced tracking within a country. For instance, while Malamud and Pop-Eleches (2011), Hall (2012) and Kerr *et al.* (2013) study the effects of deferring tracking to a later age, Guyon *et al.* (2012) investigate the effects of an increase in the share of students admitted to the academic (grammar) school track. Both the across-country and within-country studies should be seen as complementary to our article: while these studies are informative about which students may benefit or lose from a tracked *versus* a non-tracked school system, or from de-tracking, they do not investigate the long-term consequences initial misallocation to tracks and the role of flexibilities built into a tracking system to remedy such misallocation – which is the focus of this article.

Studies surveyed comprehensively by Betts (2011) analyse the effects of tracking within schools, as often practised in the US. Most of these earlier studies do not take into account the sorting of students into tracks, or into schools that offer tracking. A study by Duflo *et al.* (2011) addresses this by randomly allocating schools to tracked and non-tracked schools. In tracked schools, students are assigned to the higher track based on a test. Similar to our study, these authors carry out a regression discontinuity design, comparing students whose test results put them at the margin between two tracks. They find no effect of attending the high track on achievement for the marginal student, a result that we complement in our natural experiment for Germany for long-term outcomes. These authors also estimate the impact of within-school tracking on the entire test score distribution, and conclude that all students – including those in the lower track – benefit from tracking. While our research design does not allow us to assess these overall effects of a tracked *versus* a non-tracked education system, an

important advantage of our study is that we are able to estimate the long-term effects (as opposed to the short-term effects, as in Duflo *et al.*, 2011) of attending a more advanced track for a group of marginal students most at risk of misallocation.

Our article is also related to the literature on school quality; in particular that on elite schools where, similar to Duflo *et al.* (2011), attendance at an elite school is determined by an entry examination. This set-up lends itself to a regression discontinuity design, where the effects of attending an elite school are estimated by comparing outcomes of students who in the entry examination scored just below or just above the attendance cut-off – which are students at the margin between elite and non-elite schools. Previous papers on this issue reach conflicting conclusions. For instance, whereas Jackson (2010) and Pop-Eleches and Urquiola (2013) find that attending better schools improves children's academic achievement, Clark (2010) and Abdulkadiroglu *et al.* (2011) find no evidence that elite schools improve standardised test scores. Since these studies focus on academic achievement before final educational choices are made, they essentially identify a short-term effect of school quality. This effect may differ considerably from the long-term effect of school quality that also depends on subsequent educational choices, which is what we study in this article.²

1.2. General Overview of the German Education System

Figure 1 provides an overview of the German education system, where students are allocated into three tracks at the end of fourth grade (around the age of 10). We designate these tracks 'high', 'medium', and 'low'. Education in the high track, the *Gymnasium* (comparable to the traditional British grammar school) lasts for nine years (grades 5–13) and prepares students for tertiary studies at such academic institutions as four-year colleges or five-year universities. Education at the low and medium track, on the other hand, lasts five (grades 5–9) and six years (grades 5–10), respectively, is less academic and prepares students for an apprenticeship in blue-collar (e.g. crafts) or white-collar occupations (e.g. office clerk but also medical assistant). For men and women born between 1961 and 1976, the cohorts focused on in the empirical analysis, the shares of who attends each track are roughly of equal size.

Although there is no strict rule (such as an entry examination) to determine which track children can attend after elementary school, elementary school teachers do make recommendations. However, in 10 out of 16 states, parents have the final word on this choice. In the remaining six states, if parents want to deviate from the teachers' recommendation, students must either have earned the required marks or pass a special test.³

In principle, students may switch between tracks at any grade throughout middle school; however, in practice, very few students (typically about 2%) do so.⁴ Hence,

² Other studies which exploit quasi-random variation to investigate the short-term effects of school quality on student achievement include Gould *et al.* (2004) and Cullen *et al.* (2005, 2006). Recently, a number of studies on the long-term effects of school quality on adult outcomes have emerged (Chetty *et al.*, 2011; Deming *et al.*, 2012). Due to a different research design, these studies do not necessarily identify the effects of school quality for the marginal student, and may thus not be directly comparable to our study.

³ This information was retrieved from www.kmk.org.

⁴ Own calculations based on the School Census for Bavaria and Hesse.

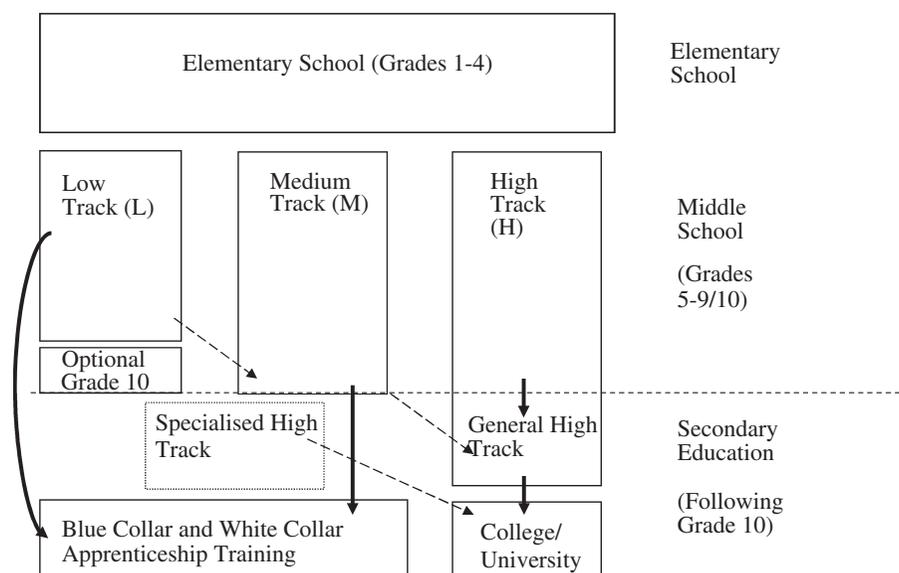


Fig. 1. *The German Education System*

Notes. The Figure provides an overview of the German education system. Students who have attended a low track school (L) in middle school (grades 5–9/10) would typically start an apprenticeship in a blue collar occupation after 9th grade. Students who have attended a medium track school (M) in middle school would typically start an apprenticeship in a white collar occupation after 10th grade. Students who have attended a high track school (H) in middle school would typically continue at this school until grade 13 and then enter college or university. Graduation from a specialised high track school grants access to college or university but possibly restricts the field of study.

once students are allocated, they are locked into their chosen track for at least five years. However, once students complete their course at the low or medium track (i.e. after ninth or tenth grade), the school system facilitates switches between tracks. In particular, at the end of ninth grade, low track students may either switch to a medium track school or, provided that their school offers this possibility, stay on for another year to earn the same school leaving qualification which they would have received from a medium track school. In addition, after tenth grade, students who graduated from a medium track school may either upgrade to a traditional high track school, or attend a high track school targeted at former medium track students. These latter often provide a special focus (e.g. agricultural, business, health, or social studies) in addition to general education, and we label them ‘specialised high track schools’ (see Figure 1). Like graduation from a general high track school, graduation from a specialised high track school grants access to college or university, but possibly restricts the field of study.

Two further factors facilitate track switching in the German education system such that students can make up for exposure to a less challenging middle school track. First, legal regulations at the state level limit German universities’ ability to pick students from particular schools. Most importantly, school marks are the main criterion for entry into almost all courses of studies and must be taken into account mechanically to

assign university places – that is regardless of whether they are from a traditional or specialised high track school and without concern for the reputation of the high track school. A second facilitating element for track changers is the overwhelmingly state-financed nature of the education system in Germany – as opposed to a largely property-tax funded school system in the US. This state financing – which is mostly based on student head counts for both schools and universities – generates a comparatively large equality in the endowment and quality between educational institutions, including universities. In particular, the concept of an elite university eludes Germany for the cohorts we study.⁵

1.3. Differences Between Tracks

The first important difference between the three tracks is that they differ with respect to teaching intensity and learning goals.⁶ We summarise the details in panel (a) of Table 1. In ninth grade (i.e. when attendance at low track schools ends), the number of hours taught per week is 36 at high but only 32 at medium and low track schools, respectively. Moreover, although the number of weekly hours in core subjects such as mathematics, German and English as a foreign language is similar across tracks, high track schools teach more hours in the second and third foreign language and natural sciences, and fewer hours in social sciences, physical education and vocational subjects (e.g. the ‘World of Work’) than low or medium track schools. In the core subjects of mathematics and German, tracks differ with respect to the topics taught as well as teaching intensity. For example, whereas low track schools put special emphasis in ninth grade on such applications as writing CVs, filling in forms and preparing for job interviews, high track schools pay special attention to detailed explanations, analysis and interpretation of various types of texts, including historical documents, and stress creative writing. Likewise, whereas ninth-grade mathematics in medium track schools covers topics such as real numbers and powers and equations with two unknowns, these topics are taught in eighth grade in high track schools. Similarly, although both medium and high track schools introduce functions, high track schools do so more intensely and cover advanced functions (e.g. exponential and broken power functions) not taught in medium track schools. Low track schools, in contrast, sometimes cover no functions at all, focusing instead on equations with rational numbers.

A second important difference is that students attending the high or medium track are surrounded by academically stronger peers than students attending the low track. According to PISA data for 2003 and 2006, average reading and mathematics test scores at high track schools are about one standard deviation higher than at medium track schools and about 1.7 standard deviations higher than at low track schools in ninth grade (see panel (b) of Table 1). These differences in peer quality across school tracks are far larger than those in the quasi-experiments by Cullen *et al.* (2006) and Pop-Eleches and Urquiola (2013) (around 0.20 of a standard deviation in both cases). The figures in the Table also

⁵ Still today, students looking for an elitist education go abroad, mostly to the Anglo-Saxon world.

⁶ The information in this paragraph was gathered from the curricula published on the web pages of the Ministries for Culture and Education of West German states. In some cases, we also contacted the ministries by telephone.

Table 1

Differences Between School Types: Peer Exposure, Teacher Quality, and Teaching Technology

	Low	Medium	High
Panel (a): teaching intensity and teaching curriculum			
(a) Teaching intensity (9th grade)			
Total hours per week	32	32	36
2nd and 3rd foreign language	0	0	6
Natural and computer science	3	6	8
Social science	3	6	4
Physical education	4	4	2
Vocational subjects	6	0	0
(b) Learning goals (9th grade)			
German:	Writing CVs, filling out forms, discussions and rules to resolve conflict	Discussions and rules to resolve conflict	Detailed explanations, analysis and interpretation of various types of texts; creative writing
Mathematics:	Equations with rational numbers; Pythagoras; prisma, pyramids, cones, cylinder; descriptive statistics	Real numbers and powers; linear equations with two unknowns; functions excluding exponential and broken polynomial functions; trigonometry, prisma, pyramids, cones, cylinder	Functions, including exponential, trigonometric and broken polynomial functions; Pythagoras, trigonometry, prisma, pyramids, cones, cylinder; stochastics
Panel (b): peer exposure (9th grade)			
Test scores			
Reading score	-0.900	-0.183	0.768
Mathematics score	-0.908	-0.217	0.840
Parental background			
Mother's education (years)	10	12	14
Father's education (years)	10	12	14
Percentage of households with less than 25 books	40	23	5
Percentage of households below median income	76	65	39
Share girls	41	49	54
Panel (c): teacher quality			
Minimum length of study	4 years	4 years	5 years
Salary	46,872	46,872	49,530

Notes. The Table reports differences in teaching intensity and learning goals in grade 9, peer exposure at age 15 and teacher quality between school tracks. Reading and Mathematics test scores are normalised to have mean zero and standard deviation 1. *Sources.* Teaching Intensity: Ministry of Education, State of Bavaria. Learning Goals: Ministries of Education of various West German states (Baden-Württemberg, Bavaria, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate). Peer Exposure: Programme for International Student Assessment (PISA), 2003 and 2006 (made available through the Research Data Centre of the Institute for Educational Progress (IQB), Berlin); own calculations. Teacher Quality: various Ministries of Education of various West German states.

show that high track students are exposed to peers whose family backgrounds are more academic than those of potential classmates at medium or low track schools and that high track students come from higher income households: only 39% live in households with a below-median income, a number that increases to 65% for medium track students and 76% for low track students.⁷ It should also be noted that track choice alone can explain more than 80% of the variation in test scores across schools in ninth grade, suggesting that schools of the same type are fairly homogeneous.

A third important difference between the three tracks is that teachers in high track schools are likely to be of higher quality than teachers in medium or low track schools. More specifically, as panel (c) of Table 1 shows, the minimum formal education for high track teachers is one year higher than that for low and medium track teachers, and their salaries are approximately 10% higher.

2. Research Design

2.1. Randomisation into Tracks

To identify a causal effect, we require an experiment that effectively randomises students of the same ability into different tracks after elementary school. Figure 2 provides an illustration of our natural experiment. Our starting point is that, because of the school entry cut-off rule, children whose birthdays fall before July 1 typically start school a year earlier than children whose birthdays are on or after July 1. Hence, although not every child complies with this law, children born shortly after the cut-off

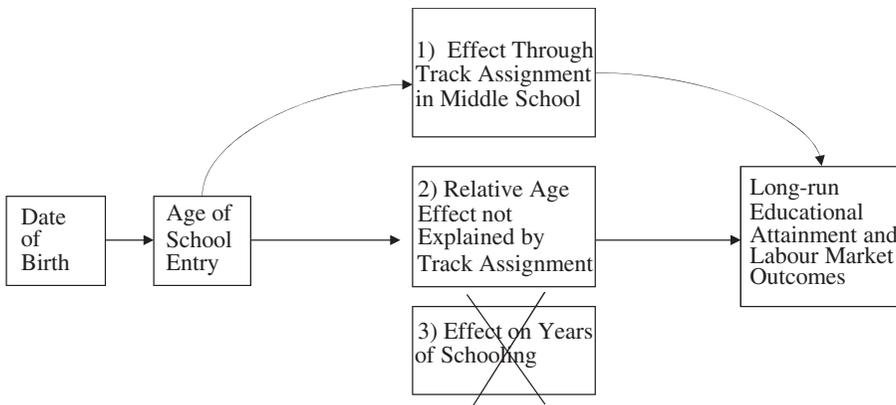


Fig. 2. *The Effects of Age of School Entry on Long-run Educational Attainment and Labour Market Outcomes*

Notes. The Figure highlights the three channels through which age of school entry may affect adult outcomes: through track assignment in middle school, through a relative age effect that may not fully dissipate over time, and through its interaction with compulsory school attendance laws. Note that due a different institutional set-up, this last effect is absent in the German education system.

⁷ Panel (b) of Table 1 also shows that the share of girls in low track schools is about 14 percentage points lower than in high track schools, which may boost the performance of boys and girls at school (Schanzenbach-Whitmore, 2009; Lavy and Schlosser, 2011) and in the labour market (Black *et al.*, 2013).

date, in July, are on average considerably older at school entry than children born shortly before the cut-off date, in June. A large body of literature has shown that age of school entry is an important determinant of early student achievement; Bedard and Dhuey (2006), Puhani and Weber (2007), Elder and Lubotsky (2009) and Schneeweiss and Zweimüller (2014). Since the decision over which track to attend is made very early in Germany, at a stage when the age of school entry effect is unlikely to have dissipated, the date of birth may, through its link to age of school entry, affect the track students attend after elementary school and, given the limited possibilities of switching during grades 5 to 9, lock them into a particular track throughout middle school (see the first effect in Figure 2). Hence, the first stage of our analysis addresses the difference in track assignment through grades 5 and 9, T , between children born in month Z , where $Z_i = 1$ if the individual is born in July rather than June:

$$\pi = E(T_i|Z_i = 1) - E(T_i|Z_i = 0). \quad (1)$$

We then investigate the impact of birth month on long-term labour market outcomes like wages and unemployment. The reduced form of our analysis is the difference in these long-term outcomes (denoted by Y) between students born in July and those born in June:

$$\eta = E(Y_i|Z_i = 1) - E(Y_i|Z_i = 0).$$

To guide the interpretation of this reduced form effect, consider the following ‘causal’ model of track attendance and long-term outcomes:

$$Y_i = a_0 + a_1 T_i + a_2 SSA_i + a_3 A_i + u_i,$$

where SSA_i denotes school starting age and A_i denotes scholastic ability, both of which determine selection into tracks and are thus correlated with T_i . For simplicity, we restrict the effects of school starting age and ability on long-term outcomes to be constant across individuals, but allow the effect of track attendance to vary across individuals. Suppose that date of birth is as good as randomly assigned and therefore independent of potential outcomes and track attendance so that $E(A_i|Z_i = 1) = E(A_i|Z_i = 0)$. We provide evidence in favour of this independence assumption below. Under this assumption, and distinguishing between three tracks, low (L), medium (M) and high (H), the reduced form effect of date of birth on long-term outcomes equals:⁸

$$\begin{aligned} \eta = & [\Pr(L_i|Z_i = 0) - \Pr(L_i|Z_i = 1)] \underbrace{E(Y_i^M - Y_i^L|M_i \text{ if } Z_i = 1, L_i \text{ if } Z_i = 0)}_{\text{LATE, } M \text{ versus } L} \\ & + [\Pr(H_i|Z_i = 1) - \Pr(H_i|Z_i = 0)] \underbrace{E(Y_i^H - Y_i^M|H_i \text{ if } Z_i = 1, M_i \text{ if } Z_i = 0)}_{\text{LATE, } H \text{ versus } M} \\ & + \underbrace{a_2 [E(SSA_i|Z_i = 1) - E(SSA_i|Z_i = 0)]}_{\text{long-term effect of SSA}}. \end{aligned} \quad (2)$$

⁸ Here, we have assumed that no individuals are shifted from the low to the high track because of their month of birth. We also require monotonicity, implying that no individuals are shifted to a less advanced track because they are older at school entry.

The first term captures the causal impact of attending the medium rather than the low track in middle school on the long-term outcomes for those individuals who attend the medium track if born in July but the low track if born in June (i.e. $E(Y_i^M - Y_i^L | M_i \text{ if } Z_i = 1, L_i \text{ if } Z_i = 0)$), multiplied with the share of children shifted between these two tracks because of month of birth (i.e. $\Pr(L_i | Z_i = 0) - \Pr(L_i | Z_i = 1)$). Similarly, the second term represents the local average treatment effect of attending the high rather than the medium track in middle school for those individuals who attend the high track if born in July but the medium track if born in June, multiplied with the share of individuals shifted between these two tracks because of their birth month. If delayed school entry conveys advantages or disadvantages even in adulthood, the reduced form estimate additionally captures this direct effect of school starting age (the third term in (2)).

2.1.1. *The exclusion restriction*

While we focus our discussion on the reduced form estimates, we can obtain the impact of track assignment in middle school on long-term outcomes by dividing the reduced form effect by the first-stage effect, $\tau = \eta/\pi$. As (2) shows, the interpretation of this parameter as the causal impact of track assignment on long-term outcomes requires an additional assumption to the independence assumption (exclusion restriction), namely that that school starting age affects long-term outcomes solely through track assignment in middle school (i.e. $a_2 = 0$). There are two reasons why this assumption may be violated. First, if date of birth, through the interaction between age of school entry and compulsory school leaving laws, affects the length of formal schooling (see the third effect in Figure 2, implying $a_2 < 0$). This is the case in the US, where students are allowed to leave school at the day of their 16th birthday.⁹ In Germany, however, this effect is absent, since students must stay in school until they at least complete 9th grade (as opposed to their 16th birthday, as in the US).

Second, the exclusion restriction would also be violated if being older at school entry has a direct impact on long-run outcomes that does not operate through track assignment in middle school (see the second effect in Figure 2, implying $a_2 > 0$). We have reviewed more than 30 articles that study the impact of age at school entry on achievements. This literature has found direct effects of age of school entry on long-run (prime age) earnings or educational attainment to be either non-existent or positive.¹⁰ None of the articles we have reviewed finds a negative effect of being older at school entry on shorter or longer term outcomes.¹¹ Therefore, even if the initial advantages of delayed school entry indeed persisted into adulthood, these effects are

⁹ This feature of the US education system was first exploited in the seminal article by Angrist and Krueger (1991), who use date of birth as an instrument for the length of formal schooling.

¹⁰ Studies that find positive effects of age of school on educational attainment or earnings include Bedard and Dhuey (2012), and Fredriksson and Öckert (2014). Black *et al.* (2011), in contrast, find little effect of age of school entry on educational attainment and earnings for individuals older than 30.

¹¹ This is apart from the mechanical effect that is instigated through individuals who are older at school entry also being older at labour market entry, so that they have, at any given age, accumulated less labour market experience than individuals who are younger at school entry, Fredriksson and Öckert (2014) and Black *et al.* (2011). We eliminate this experience effect using various methods (see subsection 4.2 for details), so that our estimates of the impact of track assignment in middle school on wages are not affected by this mechanism.

likely to be positive, leading to an upward bias in our estimates. Because we do not find a significantly positive effect of date of birth on long-term outcomes, this reasoning reinforces our finding that a more advanced track assignment in middle school has no positive effects on adult outcomes.

2.1.2. *The independence assumption*

The causal interpretation of the reduced form estimate (and thus the IV estimate) further hinges on the independence assumption, which in our baseline specification entails that whether a child is born in June or July is random. In the regression discontinuity estimates that exploit the exact date of birth (see below), the independence assumption requires that whether a child is born just before or just after the school entry cut-off date (i.e. on June 30 or July 1) is random. Note that since we are comparing individuals born within the same season, this independence assumption is considerably weaker here than in studies that use birth quarter as an instrument.

This assumption could be violated if parents timed the birth of their children to take advantage of a later school start age. This is unlikely in our case, as the school entry rule was not rigidly enforced and parents could decide against that rule if they felt strongly about it. To assess more formally whether the independence assumption is violated, we have implemented a test for bunching of births around the age of school entry cut-off, based on McCrary (2008). We find no evidence for bunching. For instance, when using a bandwidth of 20 days, we obtain a discontinuity between June 30 and July 1 of 0.0052 (in log difference), with a standard error of 0.0038. We obtain similar estimates for any day between May 1st and August 31st.¹²

We have also compared the parental characteristics of children born in July *versus* those born in June using German Microcensus data for 2005 (made available through the Research Data Centre of the Federal and State Statistical Offices, see Table A1). We find no significant differences between children born in July and those born in June in terms of parental education and their age at the children's birth.

2.1.3. *The group of compliers*

Equation (2) illustrates that the reduced form estimates are informative about the causal long-term effects of attending a more advanced track for a particular group of individuals: those individuals who attend a more or less advanced track because of their birth month. Who are these 'compliers'? Students at the top of the (expected) ability distribution are likely to attend the high track, whereas students at the bottom of the distribution are likely to attend the low track, regardless of their date of birth. Hence, the compliers are likely to be students at the margin between two tracks. This group is particularly interesting because it consists of children whose teachers and parents may

¹² These estimates are based on the number of individuals born on a given day observed in the social security data and therefore include only those individuals who at least once had a job covered by the social security system. Hence, a discontinuity could potentially arise for two reasons: first, because parents may time their births to take advantage of age of school entry rules. Second, because delayed school entry might affect the probability of having held at least one job within the social security system. Our findings suggest that neither is important. Detailed results can be found in subsection B.1 of the online Appendix B.

be unsure of which track the student should attend after elementary school and who are therefore most at risk of misallocation – and for whom small differences in the perceived learning potential at the end of elementary school could potentially lead to large differences in adult outcomes.

We develop a stylised model of track choice in online Appendix C which formalises the shifting of students to a different track because of birth month; this model is not necessary to understand the article but formalises the intuition outlined above (see Proposition 1). The model also clarifies how the key differences between school tracks (i.e. teaching technology, peer quality and teacher quality) and the costs of switching between tracks may affect completed education (see Proposition 2) and long-term labour market outcomes (see Proposition 3).

2.2. Implementation

2.2.1. Reduced form estimates

To implement our empirical strategy, we estimate reduced form effects η by replacing the population means in (1) and (2) with their sample means, while controlling for birth year and gender effects.¹³ We also report regression discontinuity estimates that exploit the student's exact date of birth.¹⁴ Specifically, we estimate regressions of the following type:

$$Y_i = \alpha_0 + h(\text{Day}_i) + \alpha_1 \text{Post}_i + \mathbf{x}'_i \alpha_2 + u_i. \quad (3)$$

Here, Day_i is the student's date of birth (normalised to be 0 on the school entry cut-off date, July 1), $h(\cdot)$ is a polynomial function of birthday, Post_i is an indicator variable equal to 1 if the student was born on or after July 1, and \mathbf{x}_i is a control variable vector that includes birth year and gender effects. The parameter of interest is α_1 , the impact of being born after the school entry cut-off date (i.e. on or after July 1) on long-term outcomes. We first estimate (3) on a sample of all students and then restrict the sample to students born within three months of the school entry cut-off date (i.e. to students born between April and September). We approximate the function $h(\text{Day}_i)$ as a polynomial function of various orders. As suggested by Lee and Card (2007), we cluster standard errors at the date of birth level.¹⁵

2.2.2. First-stage estimates

Due to lack of precise information on date of birth in the German Microcensus (see subsection 3.2), we are not able to estimate the same specifications for the first-stage estimates for the same birth cohorts. We instead compare track attendance in middle school of students born earlier (i.e. between January and April) and later (i.e. between May and December) during the year (instead of June/July). In subsection 4.1, we provide evidence that this is likely to lead to an underestimate in the first-stage

¹³ Our results remain almost unchanged if we exclude these control variables from the regressions.

¹⁴ We cannot do this for the first-stage effect because our data sets provide information only on birth month or whether the pupil was born earlier or later during the year; see subsections 3.2 and 3.3 for details.

¹⁵ Our baseline estimate comparing individuals born in June with those born in July may also be seen as a regression discontinuity estimate in which the sample is restricted to students born within two months of the school entry cut-off date and the birthday effect ($h(\cdot)$ in (3)) is assumed to be constant.

estimates, which causes bias away from zero in the estimate of our local average treatment effect $\hat{\tau}$.

3. Data

Our empirical analysis combines four main data sources, described below. Throughout the analysis, we exclude foreign citizens from our sample because they may have migrated to Germany after beginning school and thus may not have been affected by the school entry cut-off date. Since a different age of school entry cut-off rule applied in East Germany, we further restrict the sample to West German residents.

3.1. *Social Security Records*

Our primary data used to estimate the reduced form equations (see (2)), which relate long-term outcomes to date of birth, come from three decades of social security records, covering 1975 to 2006. These data, collected for every individual covered by the social security system, include detailed information on variables such as education, wages, unemployment, occupation and the exact date of birth. Not included are civil servants, the self-employed and military personnel. A comparison of the number of observations in the Social Security Records and the number of births in the Birth Register data suggests that at least 84% individuals enter the data base at some point in their career.¹⁶

From this data base, we select all men and women born between 1961 and 1976. The 1961 cohort is the first cohort for which the effective school entry cut-off falls between June and July. The 1976 cohort is 30 years old in the last year of our data and should thus have completed post-secondary education. For these cohorts, we observe the entire work history from labour market entry onwards, which allows precise computation of their potential and actual labour market experiences. The wage variable refers to April 30 of each year and is deflated, using the Consumer Price Index, with 1995 as the base year.¹⁷ We distinguish four educational categories: 'no post-secondary education' refers to individuals who graduated from the low or medium track and did not complete an apprenticeship; 'apprenticeship' includes individuals who completed an apprenticeship (as part of the formal German vocational education system) but did not complete college or university, regardless of track completed;¹⁸ and 'college' and 'university' refer to individuals who have graduated from four-year college or five-year university, respectively. Our unemployment variable refers to registered unemployment.

¹⁶ This is the average of the ratio between the number of individuals in the social security data – which exclude foreign citizens – and the number of total births in West Germany – which include foreign citizens – and thus provides a lower bound for the share of West German citizens who enter the data base at some point.

¹⁷ In our data, up to 5% of the observations are top-coded at the highest wage level for which social security contributions must be paid. In imputing the censored part of the wage distribution, we assume that residuals are normally distributed and allow for heterogeneity in the variance by age group; see Dustmann *et al.* (2009) for details.

¹⁸ An apprenticeship in Germany is a structured 2–3 years training programme for a particular occupation that combines on the job training in a firm with certified training personnel and state-provided academic education specific to the chosen occupation.

3.2. *Microcensus*

Our second data come from the scientific use files of the German Microcensus for 1976, 1978, 1980, 1982, 1985 and 1987 (made available through the Research Data Centre of the Federal and State Statistical Offices). We use these data to estimate the first-stage equations (see (1)) which relate track assignment in middle school to date of birth. We restrict the sample to the same birth cohorts as for the social security records, 1961 to 1976. Rather than specifying the exact birth month, the Microcensus provides only a binary indicator for individuals' being born either during the January to April period or the May to December period. Comparing these two periods is likely to yield an underestimate of the first-stage since the school entry cut off falls in June/July. We assess this using data from the recent School Census for Bavaria and Hesse, which do contain information on birth month but are unfortunately not available for the earlier school cohorts studied here.

3.3. *School Census*

The School Census for Bavaria and Hesse covers all students attending general and vocational schools in these two German states. It was made available for the academic school years 2004/5 to 2008/9 for Bavaria and for the academic school years 2002/3 to 2008/9 for Hesse by the corresponding state statistical offices. The data set does include information on track and grade attended, as well as on birth month. We use these data to assess the downward bias in our first-stage estimates resulting from the lack of exact birth month information in the Microcensus data, for the 1990 to 1994 birth cohorts in Bavaria and the 1988 to 1994 birth cohorts in Hesse respectively. We also use them to illustrate the impact of birth month on the probability that the student graduates from a specialised or general high track school, for the 1986–7 birth cohorts in Bavaria and the 1984–7 birth cohorts in Hesse respectively.

3.4. *1987 Census*

Our fourth data source is the 1987 census (made available by the State Statistical Office of Rhineland-Palatinate) which, unlike the social security records, contains information on the school track individuals graduated from. Like the German Microcensus, however, the 1987 census (the last census in Germany before the 2011 census) includes no information on exact birth month, asking respondents instead whether they were born before or after May 24. We use these data to estimate the effect of being born later *versus* earlier in the year on the probability that the student graduates from a low, medium or high track school for the 1961 to 1963 birth cohorts who were between 24 and 26 years old at the time of the census and should thus have completed their secondary education. Unlike the School Census, the 1987 Census does not allow us to distinguish between graduation from a general or specialised high track school.

Table 2
Date of Birth and Track Attendance at Age 14 (First Stage)

	(1) High <i>versus</i> medium or low	(2) High or medium <i>versus</i> low	(3) Sum
Panel (a): birth cohorts 1961–76 (Microcensus)			
May–December <i>versus</i> January–April	0.020 (0.005)**	0.019 (0.005)**	0.039 (0.009)**
<i>N</i> = 37,808			
Panel (b): measurement error and seasonal effects (school census, birth cohorts 1988–94)			
(i) July <i>versus</i> June	0.052 (0.002)**	0.042 (0.002)**	0.094 (0.004)**
SE			
<i>N</i> = 170,832			
(ii) May–December <i>versus</i> January–April	0.033 (0.001)**	0.039 (0.001)**	0.072 (0.002)**
SE			
<i>N</i> = 990,854			

Notes. In panel (a), we report, for selected cohorts born between 1961 and 1976, the difference in the share of students who attend the high (*versus* the medium or low) track (column (1)) or the low (*versus* the medium or high) track (column (2)) at age 14 between students born later (May to December) and earlier (January to April) during the year. In column (3), the dependent variable is coded 2 if the students is in the high track, 1 if she is in the medium track and 0 if she is in the low track, corresponding to the sum of the coefficients in the first two columns. In panel (b), we report the impact of date of birth on track attendance at age 14 for the birth cohorts 1988 to 1994, using two different cut-offs. Robust standard errors in parentheses. Coefficients with * are statistically significant at the 5% level, those with ** at the 1% level. *Sources.* Panel (a): Microcensus, selected years 1976 to 1987, men and women. Panel (b): School Census for Bavaria and Hesse, 2002–9. Own calculations.

4. Results

4.1. *The Impact of Date of Birth on Track Assignment in Middle School*

We first investigate the effect of date of birth on track assignment in middle school, which is the first stage of our analysis. Since the opportunities to switch tracks between grade 5 and 9 are limited (see subsection 1.2), we proxy track assignment in middle school by the track attended at age 14.

Our results in panel (a) of Table 2, based on the German Microcensus, show that children born later in the year (May to December) are 2.0 percentage points more likely to attend a high track at age 14 and 1.9 percentage points less likely to attend a low track at age 14 than children born earlier in the year (January to April), for a total effect of 3.9 percentage points. As Table A2 shows, this effect is strongly persistent throughout grades 5 to 9. Based on data from the School Census, the estimates indicate that the effect of date of birth on track assignment is roughly constant throughout middle school.¹⁹

Since the Microcensus lacks information on birth month, these estimates compare children born before and after the end of April, rather than children born before 30 June

¹⁹ It follows from these estimates that birth month roughly shifts as many students between the low and the medium track ($\Pr(L|Z_i = 0) - \Pr(L|Z_i = 1) = 0.019$) as between the medium and high track ($\Pr(H|Z_i = 1) - \Pr(H|Z_i = 0) = 0.020$). This implies that the relative weight for the local average treatment effect on long-term outcomes of attending a medium as opposed to a low track school is 0.49 ($0.019/0.039$), while the relative weight for the local average treatment effect of attending a high as opposed to a medium track school is 0.51 ($0.020/0.039$).

and after 30 June. As discussed in subsection 3.2, this is likely to lead to underestimation in our first-stage regression because it introduces measurement error in the age of school entry. We investigate this possibility using the School Census, which contains information on birth month (although only for recent cohorts who have not entered the labour market yet). Using this data source, we find that children born in July are 5.2 percentage points more likely to attend a high track school and 4.2 percentage points less likely to attend a low track than children born in June, for a total effect of 9.4 percentage points (row (i) of panel (b), Table 2).²⁰ If instead we reconstruct the same aggregation as in the Microcensus and compare the track assignment of children born between May and December with those born between January and April, we find a smaller first-stage estimate of 7.2 percentage points (row (ii) of panel (b), Table 2). This suggests indeed that the first-stage estimate of 3.9 percentage points in panel (a) of Table 2 is likely to be an underestimate of the impact of date of birth on track attendance.

Even after adjusting for measurement error, the first-stage results for the recent cohorts in the School Census appear stronger than those for the older cohorts in the Microcensus (7.2 *versus* 3.9 percentage points). In Appendix A.2, we provide evidence that this difference can be fully explained by the earlier cohorts' being less compliant with the school entry age cut-off rule than the more recent cohorts. Hence, the mechanism generating the date-of-birth effect on track choice – namely, that age of school entry increases the likelihood of attending a more advanced track – seems to be similar for both earlier and more recent cohorts.

4.2. *Date of Birth, Track Assignment in Middle School, and Long-term Labour Market Outcomes*

The previous Section shows that the date of birth has a precisely estimated and sizeable effect on track assignment in middle school, with at least 3.9% of students shifted to a different track because of their date of birth. Thus, since the differences between tracks are large (see subsection 1.3), and since only the high track leads to direct admission at colleges and universities, we would expect to find sizeable effects of date of birth on long-term labour market outcomes, such as wages, employment and occupational choice. This is what we investigate in this Section, starting with the impact on wages. Our analysis draws on data from the social security records and restricts the sample to men aged 30 and over.²¹

4.2.1. *Wages*

One problem with assessing the effect of date of birth and hence track assignment on wages is that individuals who are born in July start school later and, hence, enter the labour market later, so that they have, at any given age, accumulated less labour market experience than individuals born in June. Panel (a) of Figure 3 illustrates this effect,

²⁰ The effect of date of birth is further illustrated in Figure A1 in Appendix A.2, where we display the share of 14 year olds attending a high (panel (a)) or a low (panel (b)) track by month of birth. The Figure shows a clear discontinuity in track assignment around the June/July school entry cut-off date, confirming that the differences in track assignment between June and July-born children are indeed driven by differences in age of school entry.

²¹ We focus on men because, as explained below, isolating the effect of track attendance in the reduced form effect given by (2) requires the estimation of returns to potential experience. This is particularly challenging for women, due to the changing selection of women into work over the life cycle.

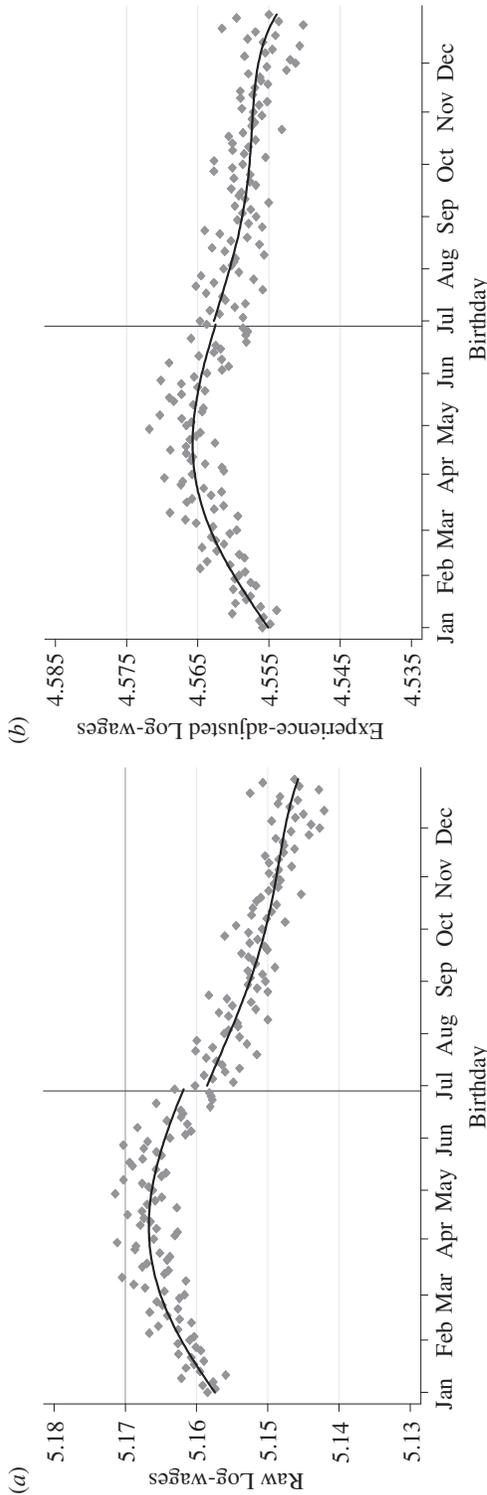


Fig. 3. *Date of Birth and Wages (Men)*. Panel (a) *Raw Log-wages*. Panel (b) *Experience-adjusted Log-wages*. Notes. The Figures plot the relationship between date of birth and raw (panel (a)) and experience-adjusted (panel (b)) log-wages. In panel (b), the experience effect is eliminated by estimating returns to potential experience using OLS, imposing a functional form of a 4th order polynomial in potential experience, and subtracting these from raw log-wages. The Figures are based on individuals working full-time aged 30 and over. Each dot refers to the average wage for two birthdays (e.g. 3 and 4 January). We also plot predicted raw and experience-adjusted log-wages obtained from a regression that controls, in addition to an indicator variable equal to 1 for individuals born after 1 July, for a polynomial of order 5 in the date of birth. The vertical lines indicate the school entry cut-off date. *Source*. Social Security Data, men, 1991–2006. Own calculations.

where we plot raw log-wages (i.e. wages unadjusted for experience) against date of birth, restricting the sample to men who are employed full-time. The Figure shows a clear wage disadvantage for men born just after the school entry cut-off date (i.e. in July), since they have accumulated less experience than individuals born just before the school entry cut-off date (i.e. in June). To isolate the causal effect of track choice in middle school on wages, we need to eliminate this experience effect. In panel (b) of Figure 3, we plot log wages adjusted for differences in experience, where we get rid of the experience effect by first estimating the returns to potential experience based on a 4th order polynomial using OLS and then subtracting these estimates from raw log wages. Panel (b) no longer shows a discontinuity around the school entry cut-off date. Thus, date of birth, and hence the track attended throughout middle school, has no noticeable impact on experience-adjusted wages for the marginal student.

Table 3 (panel (a)) confirms this conclusion and presents reduced form estimates for different specifications of (3). While in column (1), we simply compare outcomes of individuals born in July with those of individuals born in June, the estimates in columns (2) to (6) differ by birth month sampling window (January–December in columns (2), (3) and (5); April–September in columns (4) and (6)) and the order of the date of birth polynomial included as a control in the discontinuity regression (5th order, 6th order, 2nd order and linear in columns (2), (3), (4)/(5), and (6) respectively). Further, estimates in columns (5) and (6) allow the slope of the control function ($h(\text{Day}_i)$) to change at the age of school entry cut-off date. As it is common in the literature, we have opted for a lower order polynomial in specifications which are based on shorter sampling windows or which allow the slope of the control function to differ to the left and the right of the cut-off date.

In row (i) of panel (a), we present estimates on raw wages unadjusted for experience. As illustrated in Figure 3, individuals born just after the school entry cut-off date earn less than individuals born just before the school entry cut-off date according to all specifications. However, once we adjust wages for experience as shown in row (ii), all reduced form estimates are statistically insignificant and closely centred around zero, ranging from (negative) 0.1% in specifications (1) and (4) to (positive) 0.03% in specification (5).²² These very small reduced form estimates suggest that – despite the stark differences between tracks – the impact of track attendance in middle school on wages is close to zero for the marginal student. Provided that the exclusion restriction holds (see subsection 2.1), we can obtain point estimates of the impact of track attendance in middle school by dividing the reduced form estimates in Table 3 by the (likely underestimated) first-stage estimate of 0.039. These two sample-2SLS estimates

²² In these regressions, older cohorts receive more weight than younger cohorts (e.g. individuals from the 1961 cohort are observed for a maximum of 16 years, whereas individuals from the 1976 cohort are observed at most once). To give each cohort the same weight in the regressions, we have re-estimated the regressions in Table 3 but collapsing all valid wage spells for an individual into one average wage. These equally weighted estimates are very similar to those reported in Table 3 once we adjust for experience (see Table B1 in online Appendix B).

Table 3
Track Attendance in Middle School, Wages, and Labour Market Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	June–July, none	January– December, pol. 5	January– December, pol. 6	April– September, pol. 2	January– December, pol. 2, different	April– September, linear, different
Panel (a): wages						
(i) Raw wages (age 30 and higher)						
Coefficient	–0.005	–0.003	–0.003	–0.004	–0.003	–0.004
SE	(0.001)**	(0.001)**	(0.001)**	(0.001)**	(0.001)*	(0.001)**
(ii) Wages net of experience (age 30 and higher)						
Coefficient	–0.0010	0.0001	0.0002	–0.0010	0.0003	–0.0009
SE	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
N	6,212,603	37,015,844	37,015,844	18,796,219	37,015,844	18,796,219
Panel (b): work experience, unemployment and occupational choice						
(i) Share days worked						
Coefficient	0.0006	–0.0002	–0.0002	0.0006	0.0003	0.0006
SE	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
(ii) Share days in unemployment						
Coefficient	–0.0000	–0.0000	–0.0000	0.0001	–0.0001	0.0001
SE	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)
N	9,427,444	56,072,148	56,072,148	28,484,838	56,072,148	28,484,838
(iii) White collar occupation						
Coefficient	–0.0005	0.0001	0.0002	–0.0016	0.0003	–0.0016
SE	(0.0011)	(0.0014)	(0.0014)	(0.0013)	(0.0013)	(0.0013)
N	6,824,025	40,624,771	40,624,771	20,630,076	40,624,771	20,630,076

Notes. In panel (a), we report reduced form estimates for the impact of date of birth on log-wages, for men working full-time aged 30 and older. Row (i) reports results for the raw log-wage. In row (ii), we eliminate the experience effect, by estimating returns to potential experience using OLS and imposing a functional form of a 4th order polynomial in potential experience. In panel (b), we report reduced form estimates for the impact of date of birth on the share of days spent working and in unemployment since labour market entry and on whether the current occupation is a white collar occupation, for men aged 30 and over. For the first two outcomes, the sample includes all men who appeared in the social security data at least once. For occupational choice, the sample is restricted to men who are observed in the social security data at a given age. In column (1), we report the difference in outcomes between individuals born in July and June. In columns (2) and (3), we display the coefficient on being born on or after July 1st from a regression that controls for a polynomial in the day of birth of order 5 and 6, respectively, and includes all individuals, born between January and December. In column (4), we restrict the sample to individuals born between April and September, and include a polynomial of order 2 in the day of birth. In column (5), we include all individuals, born between January and December, and control for a polynomial of order 2 in the day of birth, allowed to be different before and after the age of school entry cut-off. In column (6), we restrict the sample to individuals born between April and September and control linearly for day of birth, allowing this effect to vary before and after the age of school entry cut-off. Standard errors are clustered at the day of birth. Coefficients with * are statistically significant at the 5% level, those with ** at the 1% level. Sources. Reduced Form: Social Security Data, men, 1991–2006. First Stage: Microcensus, selected years 1976 to 1987. Own calculations.

are likewise close to zero, ranging from from (negative) 2.5% (specification (1)) to (positive) 0.9% (specification (5)), with 95% confidence intervals of [–0.074, 0.024] and [–0.050, 0.068], respectively.²³

²³ We compute the variance of the TS-2SLS estimate $\hat{\tau}$ as $\text{Var}(\hat{\tau}) = \text{Var}(\hat{\eta}/\hat{\pi}) = \hat{\pi}^2 \text{Var}(\hat{\eta}) + \hat{\eta}^2 \text{Var}(\hat{\pi})/\hat{\pi}^4$, whose square root is the estimate of the standard error (when variances in the formula must be replaced by their estimates). Note that both the point estimates and the lengths of the confidence intervals are likely to be exaggerated, as the first-stage estimate of 0.039 is underestimated, as we explain above.

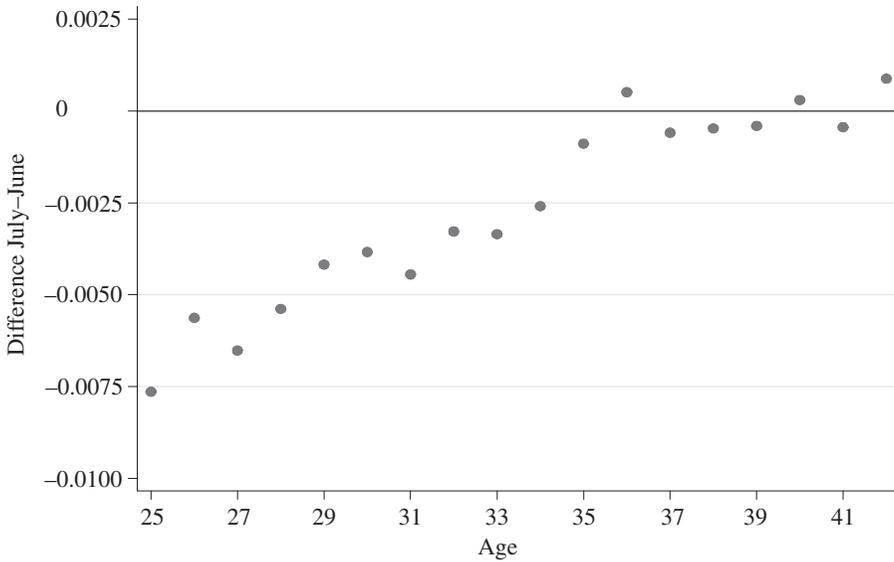


Fig. 4. *Log Wage Differences, July-born Versus June-born, by Age*

Notes. This Figure plots the difference in log-wages between men born in July and June by age, for birth cohorts 1961 to 1964.

Source. Social Security Data, men, 1991–2006. Own calculations.

Next, we show that the reduced form estimates remain close to zero no matter how we account for the difference in potential experience of individuals born shortly before and shortly after the age of school entry cut off. In Figure 4, we plot the difference in unadjusted log wages between individuals born in June and July against age, for men born between 1961 and 1964 whom we follow into the labour market until they are at least 42 years of age. The Figure clearly shows that for young ages, individuals born in July earn lower wages than individuals born in June, due to lower labour market experience of July born individuals. However, this differential decreases with age and disappears in the late 30s, reflecting the flattening out of wage-age profiles at higher ages. In Table 4, we present additional estimates which use alternative ways of adjusting the raw log wage differential for differences in potential experience, focusing on individuals born within one month of each side of the age of school entry cut off, as in column (1) of Table 3. In column (2) of Table 4, we allow for a more flexible functional form using a set of dummy variables to model the returns to potential experience (instead of a 4th order polynomial as in column (1)). Results are almost identical. In columns (3) and (4), we restrict the sample to individuals aged 40 years and older whose wages are flat with respect to potential experience. In line with Figure 4, for these individuals, both the raw and experience-adjusted wage differentials are very small and not statistically significant from zero. Our reduced form estimates of the impact of date of birth on wages therefore do not depend on the particular way we eliminate the experience effect.

Table 4
Date of Birth and Wages: Robustness Checks

	Birth Cohorts 1961–76, age 30 and up		Birth Cohorts 1961–4, age 40 and up	
	(1) Baseline OLS, pol. 4	(2) Alt. functional form OLS, dummies	(3) Raw	(6) Exp.-adjusted OLS, pol. 4
July <i>versus</i> June Coefficient	–0.0010	–0.0009	0.0000	–0.0002
SE	(0.0010)	(0.0010)	(0.0019)	(0.0019)

Notes. The Table reports various robustness checks for the impact of birth month on log-wages. Columns (1) to (2) refer to birth cohorts 1961 to 1976 and men working full-time aged 30 and older. For comparison, we report our baseline estimate in column (1) where returns to potential experience are estimated using OLS and a functional form of a 4th order polynomial in potential experience is imposed. In column (2), we relax the functional form assumption and include a full set of dummy variables for potential experience instead. Columns (3) and (4) refer to birth cohorts 1961 to 1964 and men working full-time aged 40 and older whose wages are nearly flat with respect to experience. We first report the raw and then the experience-adjusted wage differential, where returns to potential experience are, as in our baseline specification, estimated using OLS and a functional form of a 4th order polynomial in potential experience is assumed. Standard errors clustered at the day of birth parentheses. Coefficients with * are statistically significant at the 5% level, those with ** at the 1% level. *Source.* Social Security Data, men, 1975–2006. Own calculations.

4.2.2. *Other labour market outcomes*

In panel (b) of Table 3 we investigate the impact date of birth may have, through track attendance in middle school, on other labour market outcomes, focusing on the share of days in registered unemployment and the share of days spent working since labour market entry (where we down-weight part-time work relative to full-time work), and current occupational choice (where we distinguish between blue and white-collar occupations). Like results in panel (a), results refer to men aged 30 and over,²⁴ but now include, for the unemployment and experience outcomes, all men who ever entered the data base,²⁵ and for occupational choice, all men observed in the data at a given age (as working full-time, part-time or as being registered as unemployed). While the effects of birth month (through track attendance in middle school) on labour force participation and unemployment are interesting in their own right, large effects on these outcomes could also potentially bias the wage results which refer only to men who at a given age are working full-time. The estimates show that the effect of date of birth on the share of days spent in unemployment or working is basically zero in all specifications. Thus, track assignment appears to have little effect on labour force participation or unemployment. For instance, when dividing the reduced form estimates by the first-stage estimate of 0.039, the two sample-2SLS estimates of track attendance in middle school on the share of days spent working since labour market entry range from 0.016 (ES: 0.016; column (1)) and –0.005 (s.e.: 0.019; columns (2) and (3)). Furthermore, these results imply that our wage results in panel (a) do not suffer from a selection bias into employment.

²⁴ We find very similar results when women are included in the sample.

²⁵ That is, if an individual does not work for a whole year at age, say, 35, we assign zero working days throughout this spell when computing the share of days spent working.

We report results for occupational choice in row (iii). Historically, the low track prepared students for apprenticeships in blue-collar occupations, whereas the medium track prepared them for apprenticeships in white-collar occupations (see subsection 1.2). Yet, the reduced form effect of date of birth on the probability that an individual works in a white collar profession is close to zero.

Overall, therefore, our findings show that date of birth has little impact on a variety of long-term labour market outcomes, such as wages, occupational choice and unemployment – although it has a strong impact on the type of track attended in middle school. This points at students who have been mistracked due to their birth month to adjust their initial track allocation at a later stage in their educational career. Our discussion in subsection 1.2 highlights that the German school system has a number of built-in possibilities that allow for such retracking after grade 9 or 10. We now investigate whether and to what extent such up and downgrading takes place.

4.3. *Up and Downgrading*

As discussed above, the German education system allows for two upgrading possibilities from medium to high track schools after middle school (i.e. after 10th grade), by changing to general high track schools, i.e. the same schools attended by high track students throughout middle school, and by attending specialised high track schools, i.e. schools specifically designed for graduates from medium track schools to gain access to college or university (see Figure 1). There may also be downgrading, through leaving a high track school after 10th grade or by not enrolling in college or university after graduating from a high track school.

4.3.1. *Movements between the medium and high track*

We first investigate movements between the medium track and general high track at the end of middle school, drawing on data from the School Census. In panel (a) of Table 5, row (i) we contrast the difference between students born in July and June in the probability of attending the high track in middle school (proxied by track attendance at age 14) with the difference in the probability of graduating from the general high track (measured at age 22). The figures point to a substantial amount of movements between the medium and general high track: whereas children born in July are 5.2 percentage points more likely to attend the high track in middle school (see also our first-stage estimates in panel (b) and row (i) of Table 2), they are only 2.0 percentage points more likely to graduate from that track. This decline could either be due to downgrading of July-born students who attend the high track in middle school and leave that track after 10th grade, or due to an upgrading of June-born students who attend the medium track in middle school and enrol in a general high track school after 10th grade. Since the share of students who are enrolled in the high track in middle school is roughly the same as the share of students who graduate from a general high track school (around 36% according to own calculations based on the School Census for Bavaria and Hesse), the decline reflects both an upgrading of students born in June, and a downgrading of students born in July.²⁶

²⁶ Since the School Census does not contain student identifiers, we are not able to investigate transitions between the medium and general high track directly.

Table 5
Track Attendance in Middle School and Track Completion

Panel (a): movements between the medium and high track		
	(1) High track attendance in middle school	(2) High track completion
<i>(i)</i> Movements between the medium and <i>general</i> high track (School Census)		
July <i>versus</i> June	0.052	0.020
SE	(0.002)**	(0.004)**
<i>(ii)</i> Movements between the medium and <i>general</i> or <i>specialised</i> high track (School Census)		
July <i>versus</i> June	0.052	-0.001
SE	(0.002)**	(0.005)
<i>(iii)</i> Movements between the medium and <i>general</i> or <i>specialised</i> high track (1987 Census)		
June–December <i>versus</i> January–May	0.020	0.000
SE	(0.005)**	(0.001)
Panel (b): movements between the low and medium track (1987 census)		
	(1) Medium or high track attendance in middle school	(2) Medium or high track completion
June–December <i>versus</i> January–May	0.019	0.003
SE	(0.005)**	(0.001)**

Notes. In column (1) of panel (a), we report the difference in high track attendance at age 14 between students born in July and June for recent cohorts in rows (i) and (ii) (see panel (b), row (i) and column (1), of Table 2), and the difference in high track attendance at age 14 between students born earlier or later during the year for older cohorts in row (iii) (see panel (a), column (1), of Table 2). In column (2), we then display in rows (i) and (ii) the difference in graduation rates from a general high track school or in graduation rates from a general or specialised high track school by age 22 between students born in July or June, for the birth cohorts 1984 to 1987. See Appendix A.3 for calculation of standard errors. In row (iii), we compare in column (2), for the birth cohorts 1961 to 1963, the share of students who graduated from a general or specialised high track school, between students who were born earlier or later during the year. In panel (b), we first report in column (1) the difference in the share of students who attend at least the medium track at age 14 between students born earlier or later during the year (see also Table 2, panel (a), column (2)). We then report, for the birth cohorts 1961 to 1963, the difference in the share of students who completed at least the medium track between students born earlier (January *versus* May) and later (June *versus* December) during the year (column (2)). Robust standard errors in parentheses. Coefficients with * are statistically significant at the 5% level, those with ** at the 1% level. *Sources.* Panel (a), rows (i) and (ii): School Census for Bavaria and Hesse, 2002–8. Panel (a), row (iii) and panel (b): column (1): Microcensus, selected years 1976 to 1987, column (2): 1987 Census. Own calculations.

These numbers consider movements between the medium and general high track only. Next, we additionally investigate movements between the medium and specialised high track. Remarkably, the difference between June and July-born children disappears entirely once we include students who graduate from a specialised high track school in our measure for high track completion (row (ii) in panel (a)). This suggests that, for marginal students who attend a different track because of their date of birth, the track attended in middle school has no impact on the probability of graduating from any high track school that grants access to college or university. It also points to the important role that specialised high track schools play in explaining why track attendance in middle school has little impact on long-term outcomes. Also note that our calculations based on

the School Census for Bavaria and Hesse show that the share of students who graduate from a general or specialised high track is at around 52%, considerably larger than the share of students who attend the high track in middle school (around 36%). This suggests that both July and June-born students upgrade from the medium to the specialised high track, but June-born students do so more frequently than July-born students.

The finding so far refers to recent birth cohorts who have not entered the labour market yet. We also confirm similar movements between the medium and any high track at the end of middle school for earlier cohorts, using data from the Microcensus and the 1987 Census (row (iii) in panel (a)): whereas being born later during the year (the 1987 Census also does not contain exact information on birth month) increases the probability of attending a high track school during middle school by 2.0 percentage points (see our first-stage estimate in panel (a) of Table 2), it has no impact on the probability of completing a general or specialised high track school.

4.3.2. *Movements between the low and medium track*

As discussed in subsection 1.2, the German school system also provides an opportunity to upgrade from a low to a medium track school after 9th grade. We investigate movements between these two tracks in panel (b) of Table 5, drawing again on data from the 1987 Census. The results indicate that there is also a substantial amount of movement between the low and medium track: whereas children born in July are 1.9 percentage points more likely to attend at least the medium track in middle school than children born in June (see our first-stage estimate in panel (a) of Table 2), they are only 0.3 percentage points more likely to graduate from at least a medium track school.

4.3.3. *Downgrading after graduation from the high track*

A third adjustment possibility exists after graduation from a (specialised or general) high track school in the form of choosing not to pursue a college or university education. We investigate this form of downgrading in Figure 5, where, based on data from the social security records, we plot the share of students who do not attend college – conditional on having graduated from a high track school (general or specialised) – against date of birth. The Figure reveals a clear discontinuity around the school entry cut-off date: among individuals who graduated from a high track school, those born after the cut-off date are about 0.7 percentage points more likely not to complete college or university than individuals born after the cut-off date.

In sum, these results provide strong evidence that students who are shifted to a more or less advanced track in middle school because of their date of birth make use of the flexibilities built into the German tracking system: they revise their track choices made after elementary school at later stages in the educational career, both in the form of upgrading to a more advanced track at the end of middle school and in the form of downgrading by not enrolling in college or university after graduation from a high track school.

4.4. *Date of Birth, Track Assignment in Middle School and Highest Degree Completed*

Given the substantial amount of up and downgrading of marginal students after middle school, how does the track attended in middle school affect the highest degree completed? We investigate this in Figure 6 where we plot the highest degree completed

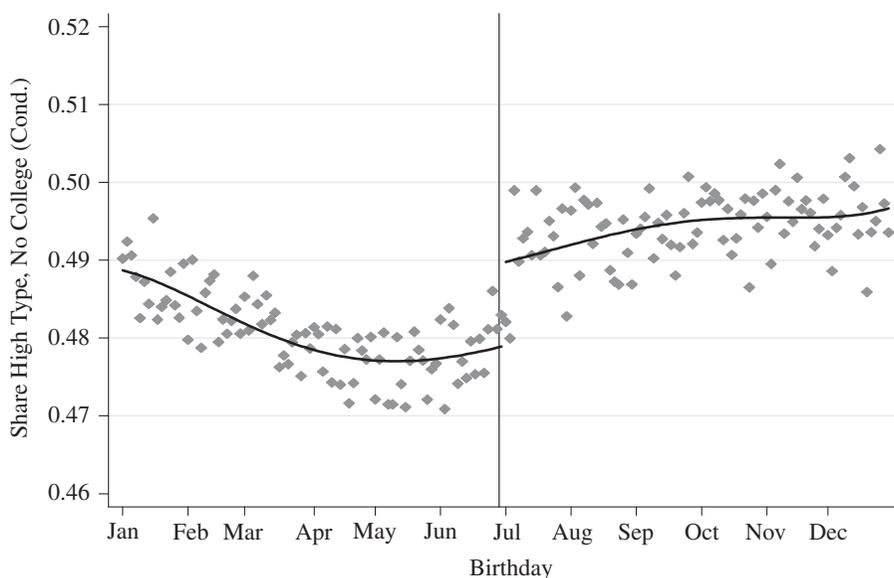


Fig. 5. *Date of Birth and Downgrading from the High Track*

Notes. The Figure plots, for individuals who have graduated from a general or specialised high school, the relationship between exact date of birth and the share of individuals who 'downgrade' by not graduating from college or university. Each dot refers to the average share for two birthdays (e.g. 3 and 4 January). We also plot predicted shares which we obtain from a regression that controls, in addition to an indicator variable equal to 1 for individuals born after 1 July, for a polynomial of order 5 in the day of birth. The vertical line indicates the school entry cut-off date. *Source.* Social Security Data, 1975–2006. Own calculations.

against date of birth, using data from the social security records. The sample consists of all men and women who ever entered the social security data base.²⁷ We distinguish between three disjoint post-secondary education outcomes: no post-secondary education (panel (a)), apprenticeship (panel (b), the typical pathway for graduates from the low or medium track), college or university (panel (c), the typical pathway for graduates from the specialised or general high track). Remarkably, neither Figure shows a clear discontinuity around the school entry cut-off date (the vertical line), suggesting that the up and downgrading that takes place after middle school fully eliminates the impact of date of birth and, hence, the track attended in middle school, on education completed.²⁸

We report the corresponding reduced form estimates in Table 6, using the same specifications as in Table 3. All specifications yield similar results, and confirm the overall picture apparent from Figure 5 that date of birth has no evident impact on education completed.²⁹ Interestingly, being born in July rather than June (and thus

²⁷ Results are very similar if we exclude women from the sample.

²⁸ The Figures reveal strong seasonal effects, with children born in April or May generally outperforming children born in January, similar to those documented by Buckles and Hungerman (2013). Note that, as emphasised in Section 2, seasonal effects do not pose a threat to our identification strategy as long as it is random whether a woman gives birth just before or just after the school entry cut-off date July 1.

²⁹ The effects of track choice can be easily obtained by dividing these coefficients by the first-stage estimate of 0.039.

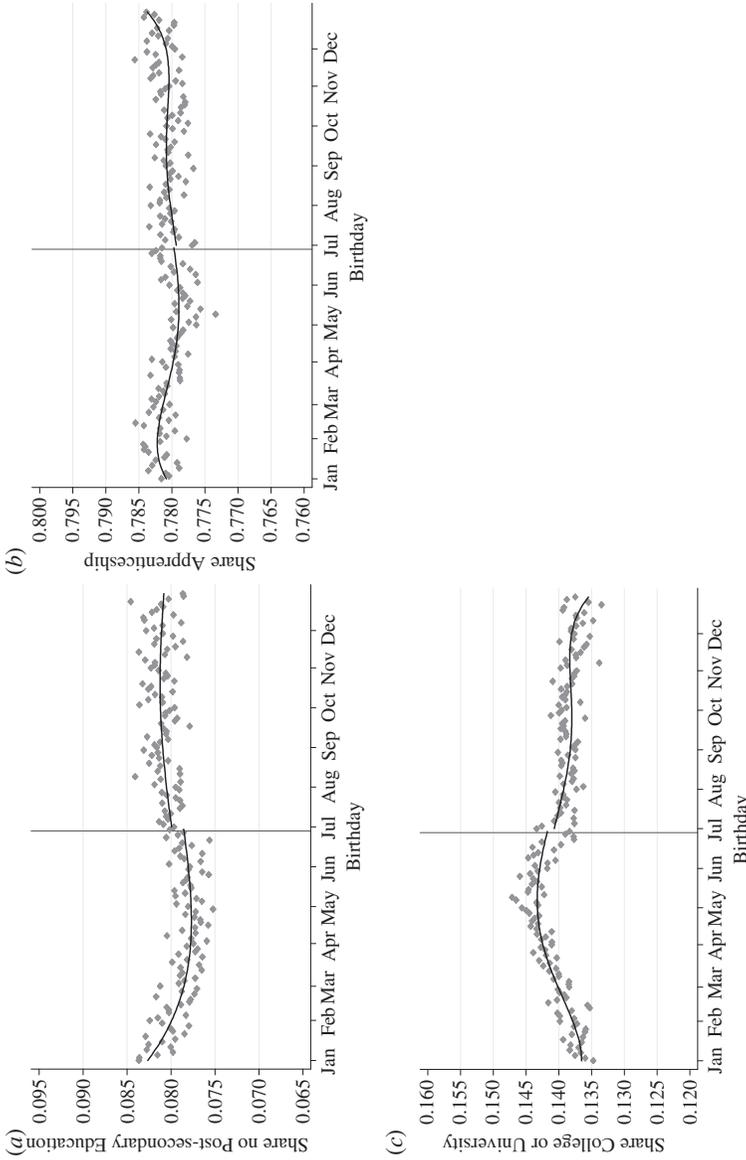


Fig. 6. Date of Birth and Completed Education. Panel (a) No Post-secondary Education. Panel (b) Apprenticeship. Panel (c) College or University

Notes. The Figures plot the relationship between exact date of birth and the share of individuals without post-secondary education (panel (a)), the share of individuals who completed an apprenticeship (panel (b)), and the share of individuals who graduated from college or university (panel (c)). Each dot refers to two birthdays (e.g. 3 and 4 January). We also plot predicted shares which we obtain from a regression that controls, in addition to an indicator variable equal to 1 for individuals born after 1 July, for a polynomial of order 5 in the date of birth. The vertical lines indicate the school entry cut-off date. Source: Social Security Data, 1975–2006. Own calculations.

Table 6

Track Attendance in Middle School and Completed Education (Reduced Form Estimates)

	(1)	(2)	(3)	(4)	(5)	(6)
	June– July, none	January– December, pol. 5	January– December, pol. 6	April– September, pol. 2	January– December, pol. 2, different	April– September, linear, different
<i>(i) No post-secondary education</i>						
Coefficient	0.0014	0.0012	0.0012	0.0016	0.0007	0.0016
SE	(0.000)**	(0.001)*	(0.001)	(0.001)**	(0.001)	(0.001)*
<i>(ii) Apprenticeship</i>						
Coefficient	0.0004	0.0000	0.0000	0.0007	0.0012	0.0007
SE	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
<i>(iii) College or university</i>						
Coefficient	–0.0018	–0.0013	–0.0012	–0.0024	–0.0020	–0.0024
SE	(0.001)**	(0.001)	(0.001)	(0.001)**	(0.001)*	(0.001)**
N	19,61,320	1,16,09,855	1,16,09,855	59,05,126	1,16,09,855	59,05,126

Notes. The Table reports various reduced form estimates for the impact of the exact (to the day) date of birth on the share of individuals without post-secondary education, the share of individuals who completed an apprenticeship or graduated from a general or specialised high school type, and the share of individuals who graduated from college or university. In column (1), we report the difference in the respective shares between individuals born in July and June. In columns (2) and (3), we display the coefficient on being born on or after 1 July from a regression that controls for a polynomial in the day of birth of order 5 and 6, respectively, and includes all individuals born between January and December. In column (4), we restrict the sample to individuals born between April and September and include a polynomial in the day of birth of order 2. In column (5), we include all individuals, born between January and December and control for a polynomial of order 2 in the day of birth, allowed to be different before and after the age of school entry cut-off. In column (6), we restrict the sample to individuals born between April and September and control linearly for day of birth, allowing this effect to vary before and after the age of school entry cut-off. Standard errors are clustered at the day of birth. Coefficients with * are statistically significant at the 5% level, those with ** at the 1% level. *Source.* Social Security Data, 1975–2006. Own calculations.

being older at school entry) appears to have, if at all, a negative effect on university or college education. This is fully consistent with the downgrading we illustrate in the previous section.

5. Discussion and Conclusions

Although a tracking system may be more efficient in tailoring education to the needs of students than a comprehensive system, it has the inherent problem of misallocating students to tracks because of incomplete or erroneous information about the student's learning potential at the time of the tracking decision. This problem may be addressed by the school system if it allows for possibilities to revise initial choices at a later stage, through providing students whose potential is higher (or lower) than initially projected with opportunities to switch tracks.

Our article is the first to analyse the long-term effects of such flexibilities for a tracking system that seems not only to be among the most rigorous, but that also tracks students earliest, around the age of 10. At the same time, this tracking system has an array of built-in possibilities allowing students to modify initial choices at a later stage, after middle school.

Our results suggest that for these marginal students (i.e. students who are close to the threshold between two different tracks), the track attended in middle school has no impact on long-term outcomes such as wages, days worked, unemployment, or occupational choice. We provide evidence that this is because these students take advantage of the flexibilities built into the tracking system and demonstrate that retracking takes the form of both an upgrading of marginal students from the middle to the high track after 10th grade and a downgrading of students who complete the high track but fail to enrol in college or university. Due to this up and downgrading, the track attended in middle school has little effect on highest degree completed for marginal students.

Not only are our results important for the debate on the merits and disadvantages of tracking systems, they also suggest that marginal students can make up for substantial weaknesses in earlier education provided they gain access to high quality schools and universities at later stages in their educational careers – even if the exposure to a less challenging school environment is prolonged (in our case 5–6 years) and the differences between school environments in terms of teaching technology and peer and teacher quality are large.

Appendix A. Additional Results

A.1. *The Impact of Birth Month and Track Assignment in Middle School*

Figure A1 plots the share of students who at age 14 were attending the high (panel (a)) or the low (panel (b)) track against birth month based on the school census data. The Figure shows a clear discontinuity in track choice around the school entry cut-off date: children born in July are 5.2 percentage points more likely to attend the high track and 4.2 percentage points less likely to attend the low track than children born in June, for a total effect of 9.4 percentage points (Tables A1 and A2).

A.2. *Comparison of First Stage for Recent Cohorts (School Census) and Older Cohorts (Microcensus)*

A comparison of the estimates in panel (a) and (b) of Table 2 clearly indicates a stronger impact of date of birth on track choice for the recent birth cohorts in Bavaria and Hesse than for the older birth cohorts in West Germany, even taking into account the measurement error in the school entry cut-off (9.4% versus 5.0%)³⁰. We next investigate whether this difference can be explained by the older cohorts being less compliant with the school entry cut-off rule than the more recent birth cohorts. Because Bavaria does not record the year of school entry, meaning we cannot compute its compliance rate, we restrict the analysis to Hesse, whose first-stage estimate is 7.3% (compared to a 9.4% first-stage estimate for Hesse and Bavaria combined). The compliance

³⁰ The latter number is computed as follows. By dividing the first-stage estimate based on children born in June or July of 9.4% (Table 2, panel (b), row (i), column (3)) with the first-stage estimate based on children born earlier or later during the year of 7.2% (Table 2, panel (b), row (ii), column (3)), we can derive an adjustment factor of 1.29 (0.094/0.072). Multiplying the estimates in panel (a) by this adjustment factor indicates that, for the 1961 to 1976 birth cohorts, children born in July are 5 percentage points more likely to attend a more academic middle school than students born in June.

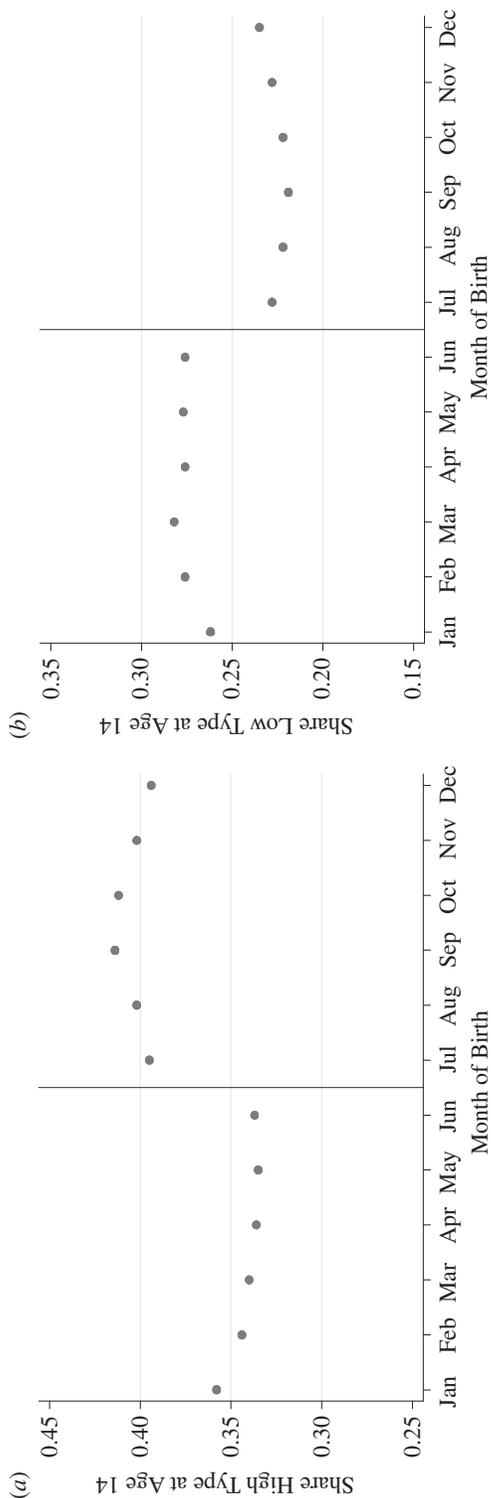


Fig. A1. Track Attendance at Age 14 and Birth Month. Panel (a): High Versus Medium or Low. Panel (b): Low Versus Medium or High. Notes. The Figures plot the share of students attending a high (panel (a)) and low (panel (b)) track in middle school at age 14 against birth month. Results refer to birth cohorts 1988 to 1994. Source: School Census for Bavaria and Hesse, 2002–9. Own calculations.

Table A1
Birth Month and Family Background Characteristics

	Father	Mother
Age	-0.14	-0.098
SE	(0.13)	(0.11)
College/university	-0.011	-0.004
SE	(0.01)	(0.01)
At least apprenticeship	-0.007	-0.004
SE	(0.01)	(0.01)
N	8,616	8,616

Notes. The Table reports the difference in age at birth (in years), college and university education, and at least apprenticeship education of fathers and mothers of children who were born in June or July, respectively. The analysis is based on the German Microcensus for the year 2005 (the only year in which the German Microcensus includes information on exact birth month), and the sample consists of all children still living with their parents who were born between 1991 and 2004 and thus were less than 14 years old at the time of the survey. *Source.* Microcensus 2005. Own calculations.

Table A2
The Stability of the First Stage Across Grades

	(1) High <i>versus</i> medium or low	(2) High or medium <i>versus</i> low	(3) Sum
Grade 5 N = 163,138	0.063 (0.002)**	0.052 (0.002)**	0.115 (0.004)**
Grade 6 N = 158,781	0.063 (0.002)**	0.052 (0.002)**	0.115 (0.004)**
Grade 7 N = 160,354	0.061 (0.002)**	0.051 (0.002)**	0.112 (0.004)**
Grade 8 N = 162,491	0.057 (0.002)**	0.048 (0.002)**	0.105 (0.004)**
Grade 9 N = 164,200	0.056 (0.002)**	0.049 (0.002)**	0.105 (0.004)**

Notes. The Table reports the difference in the share of students who attend a high *versus* a medium or low track (column (1)), and in the share of students who attend the low *versus* the medium or high track (column (2)) between students born in July and June through grade 5 to grade 9. In column (3), the dependent variable is coded 2 if the student is in the high track, 1 if she is in the medium track and 0 if she is in the low track, corresponding to the sum of the coefficients in the first two columns. Robust standard errors in parentheses. Coefficients with * are statistically significant at the 5% level, those with ** at the 1% level. *Source.* School Census for Bavaria and Hesse, 2002–9. Own calculations.

rate for the recent birth cohorts in Hesse is 33.5%, whereas that for the older birth cohorts (here proxied by the 1963 birth cohort in the 1970 Census for West Germany, made available by the State Statistical Office of Rhineland-Palatinate) is only 21.9%.³¹ To estimate the impact of

³¹ Children in the 1963 cohort who were born in July to December should not yet have been in school when the census was carried out in spring 1970, whereas children born in January to June should have already been attending school. However, regressing an indicator for school attendance on an indicator for being born in July or June results in a coefficient of only 0.219; that is, a compliance with the school entry cut-off rule of 21.9%.

relative age (i.e. being one year older at school entry) on track choice, we divide the effect of birth month on track choice by the effect of birth month on age of school entry and obtain an effect of 23.0 percentage points (0.050/0.219) for the older birth cohorts. For the younger birth cohorts, we estimate a very similar number: 21.8 percentage points (0.078/0.335). Hence, the lower first-stage results for the 1961–76 cohorts in West Germany than for the recent cohorts in Bavaria and Hesse are wholly explained by the older cohorts being less compliant with the school entry age cut-off rule than more recent cohorts.

A.3. Birth Month and Graduation from the Higher School Track

Because the school census contains no direct information on degrees obtained, we proxy graduation from the general high track by first counting the number of students who, by age 17, 18, and onward, had ever attended a general high track school in grade 13, making sure not to double count students who repeated a grade. Because students drop out of the census on leaving school, we divide this number by the total number of children born in the month, year, and state. We proxy graduation from a specialised high track school as the ratio of the number of students who by age 22 had ever attended a specialised high track school in grade 12 to the total number of children born in the month, year and state:

$$\hat{p} = \frac{\text{no. ever reached grade 13 (12)}}{\text{no. births}}.$$

The standard error of this share is estimated as the square root of:

$$\text{Var}(\hat{p}) = \frac{\hat{p}(1 - \hat{p})}{\text{no. births}}.$$

The variance of the difference in the shares between July and June born children is given by:

$$\text{Var}(\hat{p}_{\text{July}} - \hat{p}_{\text{June}}) = \frac{\hat{p}_{\text{July}}(1 - \hat{p}_{\text{July}})}{\text{no. births}_{\text{July}}} + \frac{\hat{p}_{\text{June}}(1 - \hat{p}_{\text{June}})}{\text{no. births}_{\text{June}}}.$$

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Additional Supporting Information may be found in the online version of this article:

Appendix B. Bunching, Coverage and Weights.

Appendix C. Model.

References

- Abdulkadiroglu, A., Angrist J.D., and Pathak P.A. (2011). 'The Elite Illusion: achievement effects of Boston and New York Exam Schools', NBER Working Paper 17264.
- Altonji, J., Elder T. and Taber, C. (2005). 'Selection on observed and unobserved variables: assessing the effectiveness of catholic schools', *Journal of Political Economy*, vol. 113(1), pp. 151–84.
- Angrist, J.D. and Krueger, A.B. (1991). 'Does compulsory school attendance affect education and earnings?', *Quarterly Journal of Economics*, vol. 106(4), pp. 979–1014.

- Bedard, K. and Dhuey, E. (2006). 'The persistence of early childhood maturity: international evidence of long-term age effects', *Quarterly Journal of Economics*, vol. 121(4), pp. 1437–72.
- Bedard, K. and Dhuey, E. (2012). 'School entry policies and skill accumulation across directly and indirectly affected individuals', *Journal of Human Resources*, vol. 47(3), pp. 583–612.
- Betts, J. (2011). 'The economics of tracking in education', in (E.A. Hanushek, S. Machin and L. Wössmann, eds.), *Handbook of the Economics of Education*, vol. 3, pp. 341–81, Amsterdam: North Holland.
- Black, S., Devereux, P. and Salvanes, K.G. (2011). 'Too young to leave the nest: the effects of school starting age', *Review of Economics and Statistics*, vol. 93(2), pp. 455–67.
- Black, S., Devereux, P. and Salvanes, K.G. (2013). 'Under pressure: the effect of peers on outcomes of young adults', *Journal of Labor Economics*, vol. 31(1), pp. 119–53.
- Buckles, K. and Hungerman, D.M. (2013). 'Season of birth and later outcomes: old questions, new answers', *Review of Economics and Statistics*, vol. 95(3), pp. 711–24.
- Bundesagentur für Arbeit. (2004). 'Arbeitsmarkt 2003', Amtliche Nachrichten der Bundesagentur für Arbeit. Sondernummer vom 15. Juli 2004. Nürnberg.
- Chetty, R., Friedman, J.N., Hilger, N., Saez, E., Whitmore Schanzenbach, D. and Yagan, D. (2011). 'How does your kindergarten classroom affect your earnings? Evidence from project star', *Quarterly Journal of Economics*, vol. 126(4), pp. 1593–660.
- Chetty, R., Friedman, J.N. and Rockoff, J. (2011). 'The long-term impacts of teachers: teacher value-added and student outcomes in adulthood', NBER Working Paper 17699.
- Clark, D. (2010). 'Selective schools and academic achievement', *B.E. Journal of Economic Analysis & Policy*, vol. 10(1), (Advances), Article 9.
- Crawford, C., Dearden, L. and Meghir, C. (2007). 'When you are born matters: the impact of date of birth on child cognitive outcomes in England', Institute for Fiscal Studies Working Paper 1006.
- Cullen, J., Jakob, B. and Levitt, S. (2005). 'The impact of school choice on student outcomes: an analysis of the Chicago public schools', *Journal of Public Economics*, vol. 89(5–6), pp. 729–60.
- Cullen, J., Jakob, B. and Levitt, S. (2006). 'The effect of school choice on student outcomes: evidence from randomized lotteries', *Econometrica*, vol. 74(5), pp. 1191–230.
- Deming, D. (2011). 'Better schools, less crime?', *Quarterly Journal of Economics*, vol. 126(4), pp. 2063–115.
- Deming, D., Hastings, J., Kane, T. and Staiger, D. (2012). 'School choice, school quality, and academic achievement', mimeo, Harvard Graduate School of Education.
- Duflo, E., Dupas, P. and Kremer, M. (2011). 'Peer effects, teacher incentives, and the impact of tracking: evidence from a randomized evaluation in Kenya', *American Economic Review*, vol. 101(5), pp. 1739–74.
- Dustmann, C., Ludsteck, J. and Schönberg, U. (2009). 'Revisiting the German wage structure', *Quarterly Journal of Economics*, vol. 124(2), pp. 843–81.
- Elder, T.E. and Lubotsky, D.H. (2009). 'Kindergarten entrance age and children's achievement: impacts of state policies, family background, and peers', *Journal of Human Resources*, vol. 44(3), pp. 641–83.
- Evans, W. and Schwab, R. (1995). 'Finishing high school and starting college: do Catholic schools make a difference?', *Quarterly Journal of Economics*, vol. 110(4), pp. 941–74.
- Figlio, D.N. and Page, M.E. (2002). 'School choice and the distributional effects of ability tracking: does separation increase inequality?', *Journal of Urban Economics*, vol. 51(3), pp. 497–514.
- Fredriksson, P. and Öckert, B. (2014). 'Life-cycle effects of age of school start', *ECONOMIC JOURNAL*, vol. 124(579), pp. 977–1004.
- Gould, E.D., Lavy, V. and Paserman, M.D. (2004). 'Immigrating to opportunity: estimating the effect of school quality using a natural experiment on Ethiopians in Israel', *Quarterly Journal of Economics*, vol. 119(2), pp. 489–526.
- Guyon, N., Maurin, E. and McNally, S. (2012). 'The effect of tracking students by ability into different schools: a natural experiment', *Journal of Human Resources*, vol. 47(3), pp. 684–721.
- Hall, C. (2012). 'The effects of reducing tracking in upper secondary school – evidence from a large-scale pilot scheme', *Journal of Human Resources*, vol. 47(1), pp. 237–69.
- Hanushek, E.A. and Wössmann, L. (2006). 'Does educational tracking affect performance and inequality? Differences-in-differences evidence across countries', *ECONOMIC JOURNAL*, vol. 116(510), pp. C63–76.
- Imbens, G. and Angrist, J. (1994). 'Identification and estimation of local average treatment effects', *Econometrica*, vol. 62(2), pp. 467–75.
- Inoue, A. and Solon, G. (2010). 'Two-sample instrumental variables estimators', *Review of Economics and Statistics*, vol. 92(3), pp. 557–61.
- Jackson, C.K. (2010). 'Do students benefit from attending better schools? Evidence from rule-based student assignments in Trinidad and Tobago', *ECONOMIC JOURNAL*, vol. 120(549), pp. 1399–429.
- Kerr, S.P., Pekkarinen, T. and Uusitalo, R. (2013). 'School tracking and development of cognitive skills', *Journal of Labor Economics*, vol. 31(3), pp. 577–602.
- Lavy, V. and Schlosser, A. (2011). 'Mechanisms and impacts of gender peer effects at school', *American Economic Journal: Applied Economics*, vol. 3(2), pp. 1–33.
- Lee, D.S. and Card, D. (2007). 'Regression discontinuity inference with specification error', *Journal of Econometrics*, vol. 142(2), pp. 655–74.

- Malamud, O. and Pop-Eleches, C. (2011). 'School tracking and access to higher education among disadvantaged groups', *Journal of Public Economics*, vol. 95(11–12), pp. 1538–49.
- McCrary, J. (2008). 'Manipulation of the running variable in the regression discontinuity design: a density rest', *Journal of Econometrics*, vol. 142(2), pp. 698–714.
- Mühlenweg, A.M. and Puhani, P.A. (2010). 'The evolution of the school-entry age effect in a school tracking system', *Journal of Human Resources*, vol. 45(2), pp. 407–35.
- Neal, D. (1997). 'The effects of Catholic secondary schooling on educational achievement', *Journal of Labor Economics*, vol. 15(1), pp. 98–123.
- Pop-Eleches, C. and Urquiola, M. (2013). 'Going to a better school: effects and behavioral responses', *American Economic Review*, vol. 103(4), pp. 1289–324.
- Puhani, P.A. and Weber, A.M. (2007). 'Does the early bird catch the worm? Instrumental variable estimates of early educational effects of age of school entry in Germany', *Empirical Economics*, vol. 32(2), pp. 359–86.
- Schanzenbach-Whitmore, D. (2009). 'Experimental estimates of peer effects', mimeo, Northwestern University.
- Schneeweiss, N. and Zweimüller, M. (2014). 'Early tracking and the misfortune of being young', *Scandinavian Journal of Economics*, vol. 116(2), pp. 394–428.
- Waldinger, F. (2007). 'Does ability tracking exacerbate the role of family background for students' test scores?', mimeo, University of Warwick.