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Geographical constraints and upper secondary track choice: does distance to schools prevent students from entering school-based programmes?

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Abstract Abundant research has shown that educational transitions are decisively shaped by prior educational attainment and students' family background. In contrast, the role of geography and spatial features during educational transitions remains less explored. Drawing on linked large-scale assessment data from Switzerland, the present study examines the role of the distance between a student's place of residence and the nearest upper secondary school as a potential barrier to entry into school-based education at the upper secondary level. In response to potentially flawed distance measures used in previous research, this study proposes a novel distance measure based on commuting times to the nearest school. Using a series of probit and mixed-effects probit models, this study finds that greater distances to schools prevent students from entering school-based programmes at the upper secondary level, although the effect sizes are comparatively modest. Overall, the results confirm previous findings on higher education that geographical distance may pose a barrier to accessing educational institutions.

Keywords Geography of opportunity · Distance to schools · Secondary education · Data linkage · Switzerland

JEL-Codes A20 · I24 · R53 · R41 · C35

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Räumliche Restriktionen und Übergänge in die nachobligatorische Bildung: Hindert die Distanz zu Schulen Lernende an der Teilnahme an allgemeinbildenden Ausbildungen?

Zusammenfassung Frühere Forschung verweist auf die grosse Bedeutung von schulischen Leistungen und sozialer Herkunft bei Bildungsübergängen. Demgegenüber ist wenig über die Rolle geografischer und räumlicher Faktoren bei Bildungsübergängen bekannt. Auf Basis von verknüpften Large-Scale Assessment Daten aus der Schweiz wird im Rahmen dieser Studie untersucht, ob und inwieweit räumliche Distanzen zwischen dem Wohnort von Lernenden und der nächstgelegenen Mittelschule eine Hürde für den Eintritt in allgemeinbildende Ausbildungen auf Sekundarstufe II darstellt. Dafür verwendet die vorliegende Studie ein neuartiges Mass für geografische Distanzen, das auf Pendelzeiten beruht. Eine Reihe von Probit und Mixed-Effects Probit Modellen zeigt, dass Lernende, die weit entfernt von der nächstgelegenen Mittelschule wohnen, mit systematisch niedrigerer Wahscheinlichkeit in allgemeinbildende Ausbildungen auf Sekundarstufe II eintreten. Es handelt sich um einen vergleichsweise geringfügigen Zusammenhang, der jedoch mit früheren Befunden im Bereich der Hochschulbildung übereinstimmt.

Schlüsselwörter Geographie der Möglichkeiten · Distanz zu Schulen · Sekundarschule · Datenverknüpfung · Schweiz

1 Introduction

Transitioning from one educational stage to the next has far-reaching consequences for learners as it sets the course for future educational pathways, opening new educational opportunities while simultaneously creating path dependencies. In many countries, the transition into upper secondary education is particularly pivotal as it paves the way for tertiary education for some while preparing others for labour market entry. A considerable amount of literature examines the various factors that lead students to pursue an academic education or enter the vocational pathway. While the effects of school-related factors as well as ascriptive characteristics—most notably that of family background, gender or ethnicity—on upper secondary track placement have been extensively studied (Becker 2003; Blossfeld et al. 2016; Jackson 2013), relatively little is known about whether and how this educational transition is affected by geography and spatial features.

Notions of geography of opportunity, a concept coined by Galster and Killen (Galster and Killen 1995) and developed further over recent years, provide an analytical perspective on the role of geographical space in educational processes (Butler and Sinclair 2020; Lubienski and Lee 2017; Rosenbaum 1995; Taylor 2010). The concept of geography of opportunity refers to structural characteristics of space as factors affecting people's life chances beyond their individual resources and preferences. The concept underlines that opportunity structures are not necessarily distributed evenly across space and that some populations may be at a disadvantage due to their place of residence (Galster 2024; Galster and Killen 1995). Uncovering spa-

tial factors that pose potential barriers to accessing educational institutions belongs to the fundamental aims of this strand of literature. The quality of local provision of schools is an evident feature that might influence students' educational choices, particularly during their post-compulsory educational pathways. A student living in a remote region with few viable schools nearby likely faces a more constrained choice than a peer living in an urban centre with plentiful educational options (Hillman 2016). Considering the financial costs and time requirements involved when commuting, long distances to educational institutions may prevent students from pursuing educational programmes offered at these institutions, even though the educational degrees obtainable there may grant the most favourable future prospects (Cullinan et al. 2013; Sixt et al. 2018; Turley 2009).

While the role distance to universities and colleges on the decision to attend tertiary education has been examined repeatedly in the past (Frenette 2006; Gibbons and Vignoles 2012; Spiess and Wrohlich 2010; White and Lee 2020), evidence at the secondary level remains limited and inconclusive (Dickerson and McIntosh 2013; Dollmann and Weißmann 2022; Falch et al. 2013; Sixt et al. 2018). The present study aims to contribute to the literature by examining whether and to what extent geographical distance to schools plays a role during students' transition into upper secondary education. Drawing on large-scale assessment data from Switzerland that was linked to data from administrative records and using a novel distance measure based on commuting times, this study finds that distances from students' places of residence to the nearest upper secondary school vary considerably, thus imposing severe restrictions on access to school-based educational programmes at the upper secondary level in peripheral regions of the country. Regression results are able to replicate previous findings on higher education, suggesting a modest negative association between distance to schools and the uptake of school-based educational programmes. While the results prove robust over different methodological approaches and specifications, future research is encouraged to investigate the role of geographical constraints on educational choices in a more confined manner.

The remainder of this study is structured as follows. The next section discusses this study's theoretical background and outlines the state of research. The third section expounds on the data and methods employed and describes the construction of a novel distance measure used in this study. After presenting the empirical results in the fourth section, concluding remarks critically discuss the findings and provide an outlook for future research.

2 Background

2.1 The spatial dimension of educational transitions

Transitions from one educational stage to the next are pivotal because they set the course for future educational pathways. The chances of a person obtaining a university degree are largely preempted by the type of educational programme this person attended during secondary education, particularly in highly stratified education systems with tracked secondary education, such as Germany, the Netherlands

or Switzerland (Hanushek and Woessmann 2006; Van de Werfhorst and Mijs 2010). A large body of evidence underlines that educational transitions are shaped by complex interrelations of school-related, sociodemographic and institutional factors. Repeated studies have found that prior educational achievement and family background are among the most influential predictors of students' track placement in secondary education (Becker 2003; Blossfeld et al. 2016; Jackson 2013).

Over and above the effects of student characteristics, it is plausible that geography and spatial features are also of importance during educational transitions. Butler and Hamnett (Butler and Hamnett 2007) proposed a simple thought experiment to underline this claim. If the provision of educational institutions was distributed evenly and homogenously across space and if different groups in the population were also distributed evenly and homogenously across space, then educational outcomes should only vary within regions—for instance, based on factors such as prior educational achievement or family background—but not between regions. Naturally, this is not what is observed in empirical research. A plethora of studies focusing on various education systems document substantial regional disparities in educational outcomes. Many studies find urban-rural divides, usually with learners from rural or peripheral regions achieving less favourable learning outcomes. For example, a vast number of previous studies find that learners living in peripheral areas are less likely to obtain university entry certificates and, eventually, participate in higher education at universities (Byun et al. 2012b, 2015; Van Maarseveen 2021; Wells et al. 2019, 2023). In a similar vein, some research finds that students living in peripheral areas exhibit less ambitious educational aspirations and tend to prefer entering less selective educational programmes (Agger et al. 2018; Byun et al. 2012a; Flohr et al. 2020; Helbig et al. 2017; Parker et al. 2016). Evidence from Switzerland reports on regional disparities in patterns of educational track choice, with those residing in rural areas being less likely to enter the academic pathway at the upper secondary level (Glauser and Becker 2016; Leemann et al. 2022).

Against the backdrop of thoroughly documented regional disparities in educational outcomes, the question arises as to which of the two sources of spatial variation suggested by Butler and Hamnett (Butler and Hamnett 2007) prevails: the spatially uneven distribution of different groups in the population or the spatially uneven provision of educational institutions? Concerning the role of geographical distance to upper secondary schools as a potential determinant of students' educational choices, the two sources of spatial variation would have contradictory implications.

If spatial variation in educational track choices is exclusively driven by the fact that groups of people with varying educational preferences and predispositions live clustered and in geographically similar places, then any associations between distance to schools and educational track choices are inherently endogenous and confounded by other factors (Gibbons and Overman 2012; Weber et al. 2005). For instance, if learners with different educational preferences live residentially segregated, track choice patterns may differ between areas irrespective of the geographical distance to upper secondary schools. Similarly, through neighbourhood effects and processes of peer interaction, students living in the same areas may align their educational preferences in accordance with the peer pressure they are subject to, which, again, may give rise to spatially different patterns of upper secondary track choice

unrelated to geographical distances (Galster 2012; Rich and Owens 2023; Sharkey and Faber 2014). In both exemplary scenarios, learners would not alter their educational preferences if—for whatever reason—the local provision of educational opportunities suddenly changed.

In contrast, if spatial variation in educational track choices results from a spatially uneven provision of educational institutions, then the geographical distance to upper secondary schools can have an independent effect on educational track choices. As often suggested in the literature, geographical distance can be characterised as a constraint associated with costs (Cullinan et al. 2013; Denzler and Wolter 2010; Falch et al. 2013; Spiess and Wrohlich 2010; Turley 2009). These may be direct costs, such as expenses for commuting, or indirect costs. Indirect costs primarily occur in the form of opportunity costs that arise, for example, due to forgone savings or commuting time that could have been invested more profitably. Following the likes of human capital theory (Becker 2009) or rational choice models (Breen and Goldthorpe 1997; Erikson and Jonsson 1996), increasing geographical distance to an educational institution should—*ceteris paribus*—decrease a learners' utility of pursuing an educational programme offered at said school.

2.2 Previous research on the effect of distance on educational choices

The role of geographical distance in educational choices has regularly attracted scientific attention over recent years. This strand of research mainly focuses on tertiary education, with only a handful of more recent studies considering the role of geographical distance in secondary education.

One of the most prominent and replicated findings from previous research concerns the negative relationship between distance to higher education institutions and participation in higher education. Studies from various countries show that school leavers with higher education entry qualifications are less likely to participate in higher education if they live far away from the nearest higher education institution (Cullinan et al. 2013; Denzler and Wolter 2010; Frenette 2006; Gibbons and Vignoles 2012; Hirschl and Smith 2020; Lourenço et al. 2020; Spiess and Wrohlich 2010; Sá et al. 2006; Turley 2009; Weßling and Bechler 2019; White and Lee 2020). Yet, when juxtaposed with other factors related to the uptake of higher education, such as prior achievement, social origin or gender, the effects of distance are comparatively modest. Similar findings on the effects of geographical distance are also found with regard to aspirations for entering higher education and study choice (Byun et al. 2012a; Denzler and Wolter 2010; Helbig et al. 2017; Parker et al. 2016).

Some studies provide evidence that geographical distance to educational institutions may not affect different groups of people uniformly. While some studies suggest that the relationship between distance and participation in higher education is non-linear (Frenette 2006; Hirschl and Smith 2020; Parker et al. 2016; Turley 2009), others find that the adverse effects of distance are more pronounced among socioeconomically disadvantaged populations (Cullinan et al. 2013; Gibbons and Vignoles 2012). Research from Ireland, for example, finds that it's only school leavers from lower-class households whose propensity to enter higher education is

negatively affected by distance. In contrast, no significant effects are found among school leavers from middle- and upper-class households (Cullinan et al. 2013).

Existing studies focusing on the effects of distance to educational institutions in secondary education provide more mixed results. In line with the findings on higher education, Falch and co-authors (Falch et al. 2013) show, drawing on Norwegian data, that geographical proximity between students' homes and schools is positively associated with on-time graduations from upper secondary education. The effect is strongest among learners with subpar prior achievement, suggesting that students at the margin of successfully graduating upper secondary education are affected the most by geographical constraints. Similarly, findings from England indicate that distance to the nearest educational institution only impacts the decision to pursue upper secondary education for learners who—based on their prior academic achievement—are at the margin of participating in upper secondary education. Moreover, when upper secondary education is distinguished by an academic and vocational branch, then greater distance to the nearest educational institution has a more substantial negative impact on entry into academic education (Dickerson and McIntosh 2013). Using data from a region in Germany, Sixt (Sixt et al. 2018) shows that students' propensity to attend baccalaureate schools—schools of the academic path in secondary education—decreases with every additional kilometre the nearest baccalaureate school is located farther away than other secondary schools. A more recent study using data from Germany finds that while the geographical distance to schools negatively affects students' aspirations of pursuing academic education at the upper secondary level, no equivalent effect can be found for the actual take-up of academic education at this stage (Dollmann and Weißmann 2022).

The role of geographical distances to educational institutions for educational choices is also discussed concerning outcomes beyond the uptake of education. Geographical distances to educational institutions lie at the centre of recent debates on mismatching, particularly in the context of colleges in the USA. There, Hillmann (Hillman 2016) coined the term "education deserts" for places where colleges are rare to non-existent, which stands in contrast to places—with predominantly White and affluent communities—where colleges are richly available. According to recent literature, spatially uneven provision of educational opportunities is found to foster undermatching where students attend colleges nearby for which they are overqualified even though they would likely succeed in more selective yet more distant colleges (Denice 2022; Lee and Pirog 2023; Lourenço et al. 2020; Ovink et al. 2018). In secondary education, a study exploiting the introduction of a new metro line in Santiago as a source of exogenous variation finds that students living near the newly opened metro stations travel farther to higher-quality schools than students in nearby areas where no metro stations were built (Herskovic 2020). Although not explicitly modelling geographical distance, Garrouste and Zaiem (Garrouste and Zaiem 2020) show for French data of ninth graders that openings of new upper secondary schools significantly increased the probability for students in neighbouring lower secondary schools to continue their studies in upper secondary education. Related findings on vocational education and training suggest that while training occupations are unevenly distributed across space (Kuhn 2022), secondary school students are more

likely to aspire to occupations that are more common in the occupational structure of their region (Flohr et al. 2020).

2.3 The present study

In light of the mixed and limited evidence on the role of geographical constraints on students' educational choices at the secondary level, this study seeks to investigate how geographical distance to upper secondary schools relates to students' track choices during the transition into upper secondary education. Characterising geographical distance as a factor related to direct and indirect costs and drawing on the assumptions of human capital theory (Becker 2009) and rational choice models (Breen and Goldthorpe 1997; Erikson and Jonsson 1996), it is expected that with increasing distance to upper secondary schools, the probability of pursuing a school-based programme at the upper secondary level decreases. Thus, the present study aims to replicate the negative effect of distance on educational choices found in several previous studies on higher education.

The lack of empirical research on how geographical constraints affect educational choices during secondary education is surprising given the analytical benefits of investigating this educational stage. First and foremost, as students in secondary education are still underage and usually coresident with their parents or legal guardians, it is unlikely that students relocate for educational purposes, as is often the case in tertiary education. Practically eliminating the option of relocating in order to reduce geographical constraints removes one important confounding factor that besets studies on the effects of distance in tertiary education. In addition, since students in secondary schools are too young to hold a driver's licence in most European countries, the different means of commuting to school are limited primarily to public and non-motorised transport, which reduces the uncertainty about the mode of transport students use and provides the ground for creating a more precise distance measure.

The present study examines the role of geographical distance on upper secondary track choice using the case of Switzerland. Due to its comparatively high degree of stratification and the historically grown importance of the vocational sector in the Swiss education system, the educational path young people choose at the upper secondary level has long-lasting consequences for their future academic and occupational outcomes (Falcon 2020; Korber and Oesch 2019). In Switzerland, the transition into upper secondary education occurs after eleven years of compulsory school, when students are usually sixteen years old. During the transition into upper secondary education, students are channelled into either school-based programmes that grant higher education entry certificates (about 29%) or primarily firm-based vocational education and training (about 64%), with only a small portion of compulsory school leavers not pursuing upper secondary education (FSO 2024a). School-based programmes comprise academically oriented education at baccalaureate schools and more vocationally oriented education at upper secondary specialised schools with subject areas such as commerce, IT or health. Given the federalist nature of Switzerland's education system, the organisation of school-based upper secondary education lies under the jurisdiction of the 26 subnational units, the cantons. Due to different entry regulations into school-based upper secondary education and disparities

in the provision of upper secondary schools, allocation to tracks varies considerably between cantons (Combet 2019; FSO 2024a; Leemann et al. 2022). Although Switzerland is a comparatively small country, its mountainous topography creates a highly variable range of spatial contexts to analyse. Yet, according to the Swiss Mobility Census (FSO 2017, 2023), around 94% of persons in education and training aged 13 to 20 use public or non-motorised transport for commuting to their educational institution.

3 Data, measures and methods

3.1 Data

A data source with broad geographical coverage is required to investigate the role of geographical constraints on upper secondary track choice. The present study draws on cross-sectional data from Switzerland's large-scale assessment study COFO (French: Vérification de l'atteinte des compétences fondamentales, German: Überprüfung des Erreichens der Grundkompetenzen), which was administered in 2016 and covers information on a total of 22,423 ninth graders from all cantons of Switzerland (Nidegger 2019). The target population of the data resembles the entire student cohort, excluding students in separated special educational needs schools, students with severe cognitive or physical impairments and students whose knowledge of the test language is insufficient to take part in the assessment. Students in the sample were selected randomly via either a single-stage or a two-step sampling scheme within schools of 23 cantons and the language regions of the remaining three bilingual cantons (Verner and Helbling 2019).

Apart from standardised assessments of educational competencies, COFO comprises a comprehensive student questionnaire covering a broad range of student characteristics presumed to be related to competence development and educational pathways. In response to missing data, multiple imputation by chained equations (White et al. 2011) as implemented in the R package *mice* (Van Buuren and Groothuis-Oudshoorn 2011) was employed. The percentage of missing values across the study variables varied between 0 and 11% (Table 1). Incomplete variables were imputed under fully conditional specification, creating 20 multiply-imputed datasets. Estimates from complete-case analyses are substantially similar to the results using multiply-imputed datasets (see Appendix C).

Information on the location of upper secondary schools was obtained from the list of all upper secondary schools recognised by the Swiss Conference of Cantonal Ministers of Education in 2016 (EDK 2024a, b, c). In particular, these schools comprise all 141 upper secondary schools with a public mandate, which grant a baccalaureate degree (French: *Maturité gymnasiale*, German: *Gymnasiale Maturität*), a specialised baccalaureate degree (French: *Maturité spécialisée*, German: *Fachmaturität*) or a diploma from an upper secondary health, commerce or IT school (French: *Certificat de culture générale*, German: *Fachmittelschulausweis*). Schools' addresses were geocoded into coordinates using an API of the OpenStreetMap search engine *Nominatim* as implemented in the R package *tidygeocoder* (Cambon et al. 2021).

Table 1 Sample Description

Variable	*N*	Mean/%	SD	Min	Max
Upper Secondary Track Choice	20,006	–	–	–	–
... School-Based Programme	4927	24.6%	–	–	–
... Non-School-Based Programme	15,079	75.4%	–	–	–
Distance to School (Minutes)	20,386	29.4	18.2	1.58	205
GPA	19,588	4.92	0.502	1	6
Experienced Grade Repetition	20,266	–	–	–	–
... No (Ref.)	16,520	81.5%	–	–	–
... Yes	3746	18.5%	–	–	–
Lower Secondary School Type	20,284	–	–	–	–
... Advanced Requirements (Ref.)	8533	42.1%	–	–	–
... Basic Requirements	7574	37.3%	–	–	–
... High Requirements	4177	20.6%	–	–	–
Academic Self-Concept	20,241	0.0038	0.881	–3	1
Positive School Attitude	20,274	–0.0462	0.908	–2	1
Perseverance	20,258	–0.0174	0.591	–2	1
Parental Education	18,136	–	–	–	–
... Compulsory Education (Ref.)	3008	16.6%	–	–	–
... Upper Secondary Education	8780	48.4%	–	–	–
... Tertiary Education	6348	35%	–	–	–
HISEI	19,589	52.4	21	12	89
Household Structure	20,289	–	–	–	–
... Single Parent Family	2748	13.5%	–	–	–
... Other (Ref.)	17,541	86.5%	–	–	–
Sex	20,386	–	–	–	–
... Male (Ref.)	10,521	51.6%	–	–	–
... Female	9865	48.4%	–	–	–
Language Spoken at Home	20,230	–	–	–	–
... Other Language (Ref.)	5084	25.1%	–	–	–
... Test Language	15,146	74.9%	–	–	–
Population of Municipality	20,386	23,051	55,845	43	396,955
Income per Capita (log)	20386	10.4	0.26	9.58	12.9
Under-24 Employment	20,386	59.1	9.05	27.4	82.3
Public Transport Density	20,386	1.12	1.37	0.1	9.6
Motorisation	20,386	563	69.1	344	715
Vote Share Swiss People's Party	19,929	30.6	13.1	2.39	88.7

Notes: GPA comprises an unweighted grade point average of students' grades in mathematics, sciences, test language and first foreign language. As models of lower secondary schooling differ between cantons, it is a common practice to group school types based on their requirement level. The measures for academic self-concept, positive attitude towards school and perseverance resemble factor scores. Income per capita refers to the mean taxable income in log-scale and is measured at the level of municipalities. Under-24 employment (percentage of residents under 24 in employment), public transport density (number of public transport stops per square kilometre) and motorisation (number of motorised vehicles per 1000 residents) are measured at the level of labour market regions comprising multiple neighbouring municipalities. Ref. refers to the reference category used in the analyses. Data: COFO 2016, own calculations.

Information on students' place of residence was obtained by linking the COFO data to register data provided by Switzerland's Federal Statistical Office (FSO 2024b, c). Since address data are unavailable due to data privacy restrictions, students' places of residence are approximated using municipality centroids or postcode region centroids if there are multiple postcode regions within a municipality (see Appendix A).

Of the 22,423 students that make up the sample of the COFO study, 575 students were dropped from the sample because they could not be identified in the register data. This group of excluded observations is comprised of individuals who did not start any upper secondary education by 2023 as well as individuals who could not be unambiguously identified in the population census and, therefore, have missing information on their place of residence. Furthermore, 1462 students were excluded from the sample because they had already entered school-based education in one of the considered upper secondary schools at the time of the survey. In total, the analytical sample covers information on 20,386 students residing in 2513 places, which is comprised of 1357 municipalities and 1156 postcode regions within municipalities.

3.2 Measures

The outcome measure resembles the type of educational programme students pursue at the upper secondary level. This variable was derived from linked register data provided by Switzerland's Federal Statistical Office (FSO 2024b). The variable takes a value of one if students have entered a school-based programme offered in one of the 141 upper secondary schools considered in this study granting a baccalaureate, a specialised baccalaureate or a diploma from upper secondary health, commerce or IT school. In contrast, the outcome variable takes a value of zero if students have entered predominantly firm-based vocational education and training granting a Federal VET Diploma (French: *Certificat fédéral de capacité*, German: *Eidgenössisches Fähigkeitszeugnis*), a Federal VET Certificate (French: *Attestation fédérale de formation professionnelle*, German: *Eidgenössisches Berufsattest*) or a Federal Vocational Baccalaureate I (French: *Maturité professionelle 1*, German: *Berufsmaturität 1*).

In previous research, there have been several approaches to measuring distance as a source of geographical constraints. The most common approach is to rely on an "as the crow flies" distance measure calculated in a geographic information system (Frenette 2006; Helbig et al. 2017; Turley 2009; White and Lee 2020). "As the crow flies" is an idiom for the shortest path between two points on a map. Other studies rely on road kilometres or kilometres along the rail network (Cullinan et al. 2013; Gibbons and Vignoles 2012; Parker et al. 2016) as a distance measure. Against the background that almost all students in Switzerland attending secondary education use public- or non-motorised transport to travel to their educational institution (FSO 2017, 2023), an approach that represents students' actual mode of commuting is preferable. Using commuting times as a measure of distance appears promising since it not only reflects students' actual costs more accurately but also implicitly accounts for topographic features, which would not be the case when using "as the crow flies" distances. Extending upon distance measures based on commuting times used in previous research (Denzler and Wolter 2010; Kuhn

2022; Weßling and Bechler 2019), the present study proposes commuting times by foot and public transport as a novel approach to measure distance. Here, distance is defined as the minimum number of minutes a student would need to travel by foot and public transport in a one-way route from their place of residence to reach any upper secondary school. Commuting times were retrieved using the *Open Journey Planner* API from the Swiss Federal Railways (SBB 2024), gathering all possible place-school connections and determining the shortest commuting time as the distance measure. Additional information on georeferencing and the construction of the distance measure is provided in Appendix A.

The presence of confounders that both affect students' track choice and their place of residence poses a challenge for isolating the effect of the distance measure. In order to exclude some potential confounders, several control variables are considered in the analyses. The first set of controls comprises school- and achievement-related factors. Next to students' GPA and the requirement level of their school type in lower secondary education, factor scores for students' academic self-concept, positive attitudes towards school and perseverance (Hupka-Brunner et al. 2016) and a dummy variable indicating whether a student experienced grade repetition are used as control variables. The second set of controls comprises sociodemographic characteristics, namely parental occupational status in terms of the highest ISEI, highest parental education, whether the student lives in a single-parent household, the primary language spoken in the parental home and students' sex. Third, several regional controls are considered to address potential confounders arising from residential segregation and regionally different opportunity structures. The regional controls comprise a number of proxy variables representing structural features of the municipality, sociocultural characteristics of the population, mobility infrastructure and regional labour market characteristics. Specifically, this set of controls includes municipalities' population, municipalities' income per capita (in log scale) (FSO 2021), the employment rate of residents younger than 24, the density of public transportation in terms of public transportation stops per square kilometre, the number of registered vehicles per 1000 residents (motorisation) at the level of labour market regions and the vote share of the Swiss People's Party (SVP/UDC), the conservative right-wing populist party, in the 2015 Swiss federal elections (FSO 2024d). Since patterns of upper secondary track allocation and the modalities of entering school-based programmes differ between cantons, dummies for cantons are also included. Table 1 provides descriptive statistics of all study variables. Additional descriptives are provided in Appendix B.

3.3 Methods

Isolating the effect of distance in terms of commuting time to the nearest school on students' choice of a school-based educational programme at the upper secondary level is challenging given that multiple competing channels exist through which the relationship between these two variables could operate (Denzler and Wolter 2010; Spiess and Wrohlich 2010). Moreover, since this study relies on cross-sectional variation only, the scope of analytical approaches capable of dealing with endogeneity

is limited. Therefore, the present study employs two complementary approaches aiming to reduce some of the concerns about omitted variables.

The first approach is to use probit models to examine upper secondary track choice (Greene 2020). Students' track choice can be represented as a latent variable Y_i^*, which linearly depends on a total of K predictor variables, including the distance measure and the set of controls.

$$Y_i^* = \alpha + \sum_{k=1}^{K} \beta_k X_i + \varepsilon_i$$

If this latent variable is non-negative, one would observe a student to pursue a school-based programme ($Y_i = 1$) – and vice versa.

$$Y_i = \begin{cases} 1 \; if & Y_i^* \geq 0 \\ 0 \; if & Y_i^* < 0 \end{cases}$$

In the presence of processes such as residential segregation or neighbourhood effects, the error terms ε_i of students living in the same municipality are unlikely to be independent. Cluster-robust standard errors are estimated to account for the lack of independence of the error terms.

The second approach explicitly models the interdependencies of students living in the same place by allowing place-specific intercepts to vary around a grand mean γ_{00}. In these mixed-effects probit models (Hox et al. 2017), students i are nested in places j, and there are P student-level and Q place-level predictors.

$$Y_{ij}^* = \gamma_{00} + \sum_{p=1}^{P} \gamma_{p0} X_{pij} + \sum_{q=1}^{Q} \gamma_{0q} Z_{qj} + \delta_{0j} + \varepsilon_{ij}$$

Across the 20 imputed datasets, intercept-only models reveal substantial nesting effects with a mean intraclass correlation coefficient (ICC) of 0.406 (SD = 0.000). The mixed-effects probit models in this analysis are specified as random intercept models where only place-specific intercepts are allowed to vary around the grand mean. With 2513 places covered in the data, the requirement of a sufficient number of clusters is easily satisfied. In contrast, the cluster size tends to fall short of common recommendations in the literature (Hox et al. 2017; McNeish and Stapleton 2016). However, according to simulation studies, small cluster sizes have little impact on bias and the type 1 error rate, provided that the number of clusters is high (Austin and Leckie 2018; Bell et al. 2014).

Some previous studies relied on instrumental variables to address endogeneity when investigating the role of geographical constraints on educational behaviours. For example, while Gibbons and Vignoles (Gibbons and Vignoles 2012) use the distance to more distant educational institutions to help control for endogeneity, Falch and co-authors (Falch et al. 2013) use municipal characteristics in the form of population density and the share of the population living in rural areas as instruments for the distance to the nearest school. In addition to the relevance assumption and the exclusion restriction, the instrumental variable approach requires the absence of

unobserved confounders that affect both the instrument and the instrumented variable. With regard to distance to the nearest upper secondary school, there are several plausible scenarios in which this assumption may not be fulfilled. For instance, both distance to school and population density are likely to be subject to urban-rural or central-peripheral divides, not only in terms of opportunity structures but also in terms of attitudes and preferences (Agger et al. 2018; Byun et al. 2012b). Therefore, there are reservations about the validity of the causal claim associated with instrumental variable estimation to examine the role of geographical constraints (Baum-Snow and Ferreira 2015; Betz et al. 2020).

The two analytical approaches are employed in a complementary fashion. Regression analyses are conducted on each of the 20 multiply-imputed data sets, and the estimates are pooled following Rubin's rules (Rubin 2018). In addition to alternative model specifications with fewer control variables (see Appendix B), additional sensitivity analyses indicate overall robustness of the findings on the effects of distance to the nearest school on students' propensity to pursue school-based education at the upper secondary level. These robustness checks include analyses with non-imputed data, analyses using alternative outcome and distance measures as well as subsample analyses (see Appendix C).

4 Results

4.1 Descriptive results

Figure 1 depicts the distance measure in terms of commuting times to the nearest upper secondary school for four exemplary regions—three cantons and one larger municipality. In all of the examples shown, there is considerable variance in commuting times to the nearest upper secondary school, which are represented by the yellow squares. Moreover, commuting times do not follow a pattern of strict contiguity since some places have shorter commuting times to the nearest school than adjacent places, which would be classified as closer to the nearest upper secondary school using an "as the crow flies" distance measure. Figure 1, thus, illustrates that a mere cartographic representation of distance may not be suitable for studying geographical constraints.

From the 2513 places represented in the COFO data, it takes, on average, 29.4 min (SD = 18.2) to reach the nearest upper secondary school. However, as illustrated in Fig. 1 and 2, accessibility of schools in terms of commuting time varies considerably across places. With a median of 26 min and an interquartile range ranging from 17 to 37 min, commuting times to the nearest upper secondary school follow a right-skewed distribution. Furthermore, the distance measure in 275 places in the data set exceeds the one-hour mark of commuting time to the nearest upper secondary school, suggesting that entering a school-based programme would involve a great deal of effort and high costs for students living in these municipalities (6.2% of the sample).

As illustrated by the lower two boxplots in Fig. 2, students who enter a school-based programme at the upper secondary level live, on average, closer to the nearest

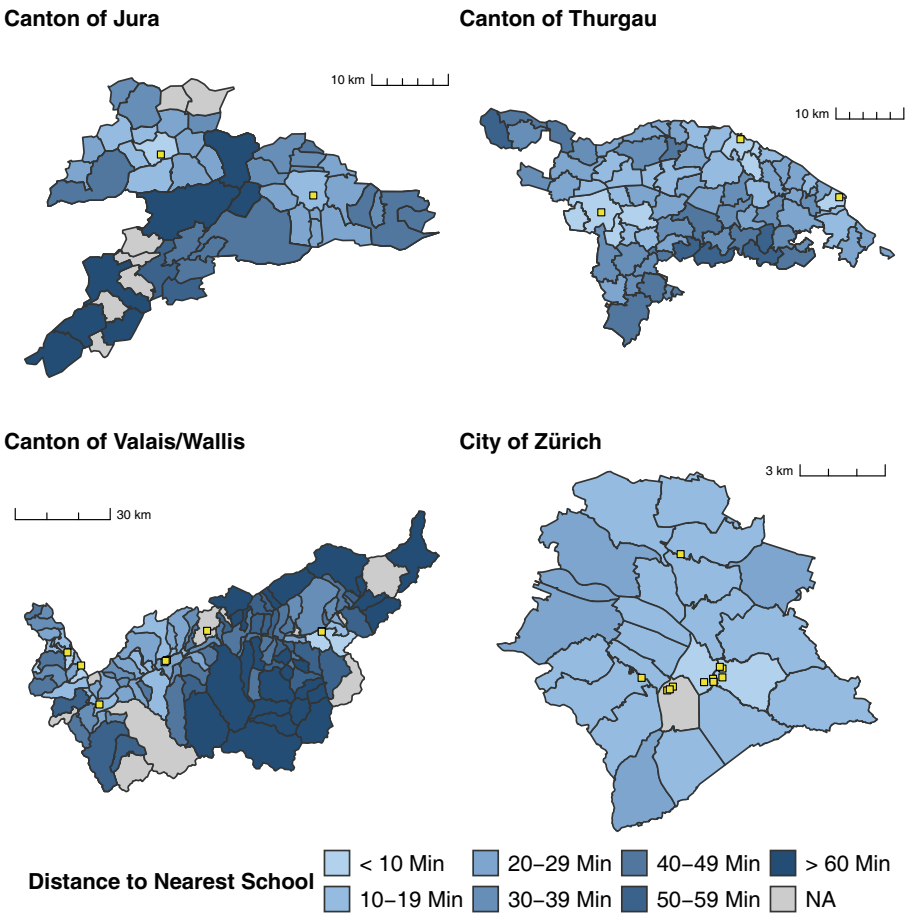

Fig. 1 Distance to the Nearest Upper Secondary School in Four Exemplary Regions. Note: See Appendix A for more information on georeferencing and the calculation of the distance measure. NA indicates that there are no students in the sample living in the corresponding municipality or postcode region. Data: COFO 2016 and SBB (2024), own calculations

upper secondary school (Mean = 27.3, SD = 17.8, Median = 23) than their counterparts who pursue non-school-based education at the upper secondary level (Mean = 30.2, SD = 18.3, Median = 27). The average difference in commuting times to the nearest school depending on upper secondary track choice is statistically significant (t = 10.0, $p < 0.001$).

Apart from students' upper secondary track choice, the COFO data points to systematic differences in distance to school across other student characteristics. Compared with students attending a school type with advanced requirements in lower secondary education (Mean = 30.1), both students in basic requirements schools (Mean = 29.0, $p < 0.001$) and high requirements schools (Mean = 28.9, $p < 0.001$) live, on average, slightly closer to the nearest upper secondary school. Similar gaps exist with regard to social origin. Students whose parents have an above-average ISEI (Mean =

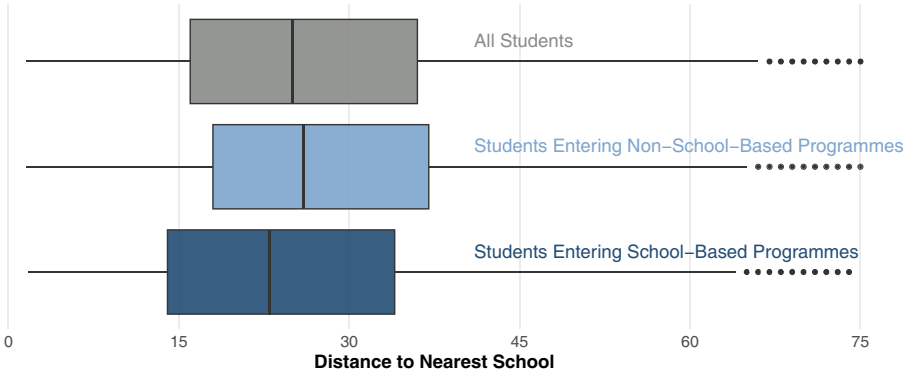

Fig. 2 Distance to the Nearest Upper Secondary School by Track Choice. Note: Boxplots of the distance measure for the entire sample ($N = 20\,386$) and the subsamples entering non-school-based programmes ($N = 15\,079$) or school-based programmes ($N = 4927$) at the upper secondary level. Distances above 75 min ($N = 536$) not shown. Data: COFO 2016, own calculations

28.8) would need to spend slightly less time commuting to the nearest upper secondary school than their counterparts whose parents have a below-average ISEI (Mean = 30.2, $p < 0.001$). A more substantial disparity in the distance measure exists between native (Mean = 30.4) and foreign language speakers (Mean = 26.5, $p < 0.001$), with the latter living closer to upper secondary schools. These systematic gaps in the distance measure illustrate that residential choices are non-random and, therefore, likely pose a source of confounding.

4.2 Multivariate results

Turning to the multivariate results, Table 2 displays regression results of the full models in terms of average marginal effects with (cluster-)robust standard errors in parentheses. Results from additional model specifications are presented in Appendix B. To illustrate the main findings, Fig. 3 depicts point estimates of the effect of distance to the nearest upper secondary school on the choice of a school-based programme at the upper secondary level for both analytical approaches and for different model specifications. The point estimates in Fig. 3 resemble average marginal effects (AME) in terms of percentage points (Pp.) for every additional minute of commuting time along with 95% confidence intervals.

Consistently across all specifications and both analytical approaches, a negative relationship is found between the distance to the nearest upper secondary school and students' propensity to enter a school-based programme at the upper secondary level. Without exception, all point estimates depicted in Fig. 3 are statistically significant at a 95% confidence level. For both analytical approaches, the negative effects of the distance measure shrink—but become more precise in terms of smaller confidence intervals—the more control variables are considered. In more substantive terms, the bivariate probit model estimates for every additional minute of commuting time a 0.236 percentage point (± 0.127 Pp., $p < 0.001$) decrease in the probability that a student pursues school-based education at the upper secondary level. Net of all

Table 2 Pooled Estimates from Probit and Mixed-Effects Probit Regression Models on Choice of School-Based Upper Secondary Education

	Probit	ME Probit
Distance to School (Minutes)	–0.00077***	–0.00066*
	(0.00011)	(0.00033)
Lower Secondary School Type (Ref. Advanced Requirements)		
Basic Requirements	–0.12158***	–0.12017***
	(0.00316)	(0.00433)
High Requirements	0.41704***	0.41329***
	(0.00530)	(0.00691)
GPA	0.08208***	0.09077***
	(0.00436)	(0.00529)
Experienced Grade Repetition (Ref. No)		
Yes	–0.01569***	–0.02029***
	(0.00335)	(0.00340)
Academic Self-Concept	0.01130***	0.00705***
	(0.00189)	(0.00204)
Positive School Attitude	0.03946***	0.03823***
	(0.00155)	(0.00167)
Perseverance	–0.01452***	–0.01455***
	(0.00229)	(0.00236)
Parental Education (Ref. Compulsory Education)		
Upper Secondary Education	–0.00488	–0.00550
	(0.00507)	(0.00534)
Tertiary Education	0.04971***	0.04255***
	(0.00554)	(0.00584)
HISEI	0.00177***	0.00156***
	(0.00007)	(0.00008)
Household Structure (Ref. Other)		
Single Parent Family	–0.01230***	–0.01135**
	(0.00370)	(0.00368)
Sex (Ref. Male)		
Female	0.09340***	0.09225***
	(0.00244)	(0.00282)
Language Spoken at Home (Ref. Foreign Language)		
Test Language	–0.03029***	–0.02416***
	(0.00335)	(0.00337)
Population of Municipality	0.00000**	0.00000*
	(0.00000)	(0.00000)
Income per Capita (log)	0.06360***	0.07540***
	(0.00605)	(0.01733)
Under-24 Employment	–0.00131***	–0.00222**
	(0.00026)	(0.00079)
Public Transport Density	0.00636***	0.00174
	(0.00188)	(0.00800)

Table 2 (Continued)

	Probit	ME Probit
Motorisation	0.00012***	0.00020
	(0.00004)	(0.00011)
Vote Share Swiss People's Party	–0.00193***	–0.00199***
	(0.00021)	(0.00056)
Canton Dummies	X	X
Observations	20,386	20,386
Places	2513	2513
AIC	48,373.131	42,143.593
M	20	20

Notes: Pooled results from multivariate probit and mixed-effects (ME) probit models in terms of average marginal effects with (cluster-) robust standard errors in parentheses. ***$p<0.001$, **$p<0.01$, *$p<0.05$. Ref. refers to the reference category. Data: COFO 2016, own calculations.

control variables, the average marginal effect in the probit model reduces to −0.077 (±0.021 Pp., $p<0.001$). When compared to the estimates from the mixed-effects probit models, the estimated negative effects from the probit models tend to be slightly stronger and have considerably smaller standard errors. In the full specification including all control variables, the average marginal effect from the mixed-effects probit model ($AME = -0.066$Pp. $\pm$ 0.064Pp.) is still negative yet only barely statistically distinguishable from zero.

In line with previous research investigating participation in higher education, geographical constraints appear to shape learners' educational choices. Greater distances and, thus, marked geographical constraints seem to prevent learners not only from participating in higher education but also from pursuing school-based programmes at the upper secondary level. The results presented here on the case of Switzerland using a novel approach to measure distance align with some of the previous findings on secondary education. For instance, Falch and co-authors (Falch et al. 2013), using a fixed-effects approach, show for Norway that every additional hour of commuting time by car decreases the propensity to graduate from upper secondary school on time by 3.7 percentage points. Similarly, Dickerson and McIntosh (Dickerson and McIntosh 2013) estimate using data from England that with each additional kilometre of "as the crow flies" distance, the likelihood of participating in academic education decreases by 1.5 percentage points.

As, for instance, the findings of Turley (Turley 2009) or Parker and co-authors (Parker et al. 2016) on higher education suggest, the negative effect of distance is not necessarily linear. Once a quadratic term is included in the models—and the distance effect is allowed to follow a curvilinear form—likelihood ratio tests indicate a significant improvement of model fit for both analytical approaches and across all model specifications. Although marginal in effect size, the quadratic terms are positive and statistically distinguishable from zero. In the full models, coefficients of the quadratic term are $\beta = 0.00007$ (SE = 0.00002, $p<0.01$) in the probit model and $\gamma = 0.00008$ (SE = 0.00003, $p<0.05$) in the mixed-effects model (see Appendix B). Coupled with the negative effects of the distance measure (probit: $\beta = -0.008$, SE = 0.003, $p<0.01$, mixed-effects probit: $\gamma = -0.009$, SE = 0.004, $p<0.05$), the

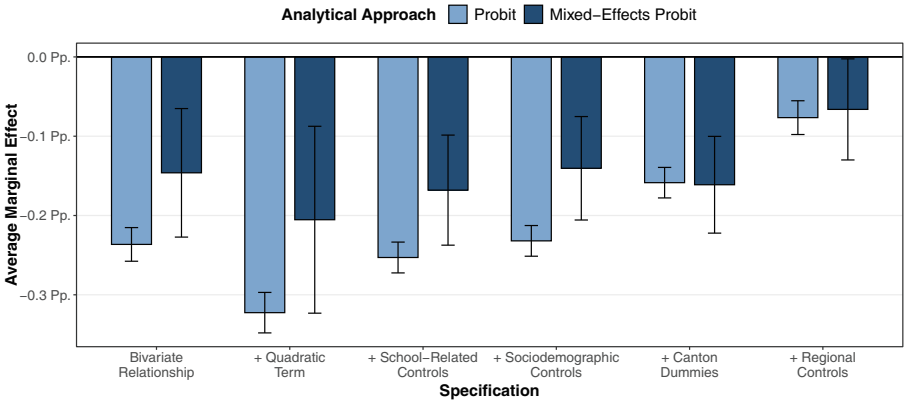

Fig. 3 Coefficient Estimates by Analytical Approach and Specification. Note: Average marginal effects with 95% confidence intervals of distance on choice of school-based upper secondary education in terms of percentage points (Pp.). Data: COFO 2016, own calculations

regression models imply a relationship where the propensity to pursue a school-based programme steeply declines at first, and then flattens out or even reverses.

To provide a more substantive interpretation of the effect of distance to the nearest school, Fig. 4 depicts adjusted predictions of pursuing school-based education at the upper secondary level along with 95% confidence intervals, which are based on the probit and mixed-effects probit models including all control variables. The left panel of Fig. 4 illustrates the effect of distance when a linear functional form is assumed. Recalling that the interquartile range ranges from 17 to 37 min, students at the 75th percentile of the distance measure are predicted to exhibit a 1.4 percentage point (probit) respectively 0.5 percentage point (mixed-effects probit) lower probability of pursuing school-based education at the upper secondary level than their counterparts at the 25th percentile. In the right panel of Fig. 4, in contrast, when the effect is allowed to follow a curvilinear form, the corresponding gap between the 25th and

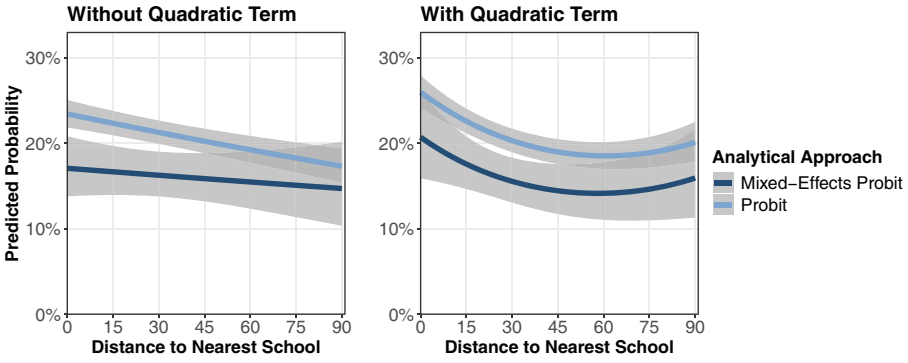

Fig. 4 Adjusted Predictions of Distance to Nearest School on the Probability of Pursuing School-Based Education. Note: Adjusted predictions with 95% confidence intervals including all control variables. Predictions of the mixed-effects models are calculated based on the grand mean. Data: COFO 2016, own calculations

75th percentile amounts to 2.7 percentage points (probit) respectively 2.3 percentage points (mixed-effects probit) in favour of those whose commuting time to the nearest upper secondary school lies at the 25th percentile. Interestingly, the right panel of Fig. 4 suggests that the probability of entering a school-based programme steadily decreases up to about 45 min of commuting time, then flattens out and only increases again—although with noticeably wider confidence intervals—with commuting times higher than 75 min. While commuting times of more than one hour are exceedingly rare and cover only 6.2% of students in the sample, considering a squared term suggest that once the expenditure of commuting time exceeds a certain threshold, the costs of commuting to school do not add up anymore.

While it has been established that the effect of distance to the nearest upper secondary school on track choice is not negligible, the effect size is somewhat modest compared to the effect sizes of school-related—and, to a lesser extent, sociodemographic—factors. For instance, according to the probit model in Table 2, students attending a lower secondary school type with high requirements are 41.7 percentage points (SE = 0.530 Pp., $p < 0.001$) more likely to pursue school-based education after the transition into upper secondary education than their counterparts in advanced requirement schools. At the same time and net of other predictors, female students are estimated to have a 9.3 percentage points (SE = 0.244 Pp., $p < 0.001$) higher probability of entering a school-based programme than male students. The observed difference in the probability of entering school-based education across the entire range of observed values of parental ISEI amounts to 13.6 percentage points ($p < 0.000$), with those whose parents have a low ISEI being less likely to pursue school-based education. The average marginal effects of the student-level predictors in the mixed-effects probit model are substantially similar in terms of effect size and statistical significance.

A considerable amount of variation can be captured by the canton dummies, which is unsurprising given that the patterns of track allocation at the upper secondary level differ vastly between cantons (Combet 2019; Leemann et al. 2022). The inclusion of regional control variables also leads to significant improvements in model fit for both analytical approaches. Most notably, students living in high-income municipalities are more likely to enter school-based programmes at the upper secondary level (probit: AME = 0.06360, SE = 0.00605; mixed-effects probit: AME = 0.07540, SE = 0.01733), while negative associations are found for the employment rate among residents under 24 years of age (probit: AME = –0.00131, SE = 0.00026; mixed-effects probit: AME = –0.00222, SE = 0.00079) and for the municipal vote share for the Swiss People's Party (probit: AME = –0.00193, SE = 0.00021; mixed-effects probit: AME = –0.00199, SE = 0.00056). In contrast to the mixed-effects probit model, the probit model estimates positive and statistically significant coefficients for public transport density and motorisation.

According to additional analyses presented in the appendix, the negative effect of distance proves substantially robust across different subgroups of students (Table C4 in Appendix C) and sample restrictions (Table C5 in Appendix C). Similar results are found when using an "as the crow flies" distance measure instead of commuting times (Table C2 in Appendix C). Moreover, the negative effect of the distance measure is not limited to selection into upper secondary tracks only but

can also be found with regards to completion of a school-based upper secondary programme as well as higher education entry (Table C3 in Appendix C).

5 Conclusion

Examining students' choices during transitions from one educational stage to the next is crucial for understanding educational inequality. It is an endeavour that has rightfully attracted abundant scientific attention in the past. While previous research has repeatedly shown that students' track choices are strongly affected by their prior achievement, social background as well as institutional features (Becker 2003; Blossfeld et al. 2016; Jackson and Jonsson 2013), the role of geography and spatial features is less explored. The present study provides empirical evidence that geography matters for educational choices in secondary education. By investigating whether students who live distant from upper secondary schools are less likely to enter school-based programmes at the upper secondary level, this study aims to contribute to the concept of geography of opportunity (Galster 2024; Galster and Killen 1995), which posits that structural features of space can affect people's live chances over and above their individual resources and preferences.

Characterised as a dimension of the opportunity structures within which students make their educational choices, the distance between a student's place of residence and the nearest school is associated with direct and indirect costs and, therefore, may act as a constraint. Drawing on administratively linked and georeferenced data from a large-scale assessment study among students at the end of lower secondary education in Switzerland and employing a novel measure of distance based on commuting times, the study finds a modest negative relationship between the distance to the nearest school and students' propensity to take up school-based education at the upper secondary level. The negative association appears to follow a non-linear form, with the steady decrease in the probability of entering school-based education flattening for longer commuting times. The findings are in line with what previous research has consistently found on participation in higher education (Cullinan et al. 2013; Gibbons and Vignoles 2012; Spiess and Wrohlich 2010) and prove robust over different analytical approaches, model specifications and subsamples.

Although the results cohere with findings from previous research and the theoretical expectations from human capital theory and rational choice frameworks, some limitations sound a word of caution. First and foremost, the investigation of the role of distance to the nearest school on students' educational choices in secondary education is beset by obvious and inherent endogeneity concerns. Processes like residential segregation and neighbourhood effects, as well as spatial interdependence and mere spatial heterogeneity, open up competing channels through which the relationship between distance to school and track choice could operate and, consequently, pose threats to the identification of causal effects (Baum-Snow and Ferreira 2015; Betz et al. 2020; Gibbons and Overman 2012). At the same time, attempts to add control variables to account for assumed unobserved processes may induce overcontrol bias and endogeneous selection bias (Grätz 2022). While it is implausible to overcome these sources of endogeneity entirely, relying on longitudi-

nal data and exploiting exogenous variation in distance or commuting times—such as openings of new schools (Garrouste and Zaiem 2020) or changes in transport infrastructure (Herskovic 2020)—could be promising paths to advance this strand of literature.

Second, this study relies on simplifications in order to make the decision-making process students face at the end of lower secondary education empirically tangible. For instance, the distance measure relies on specific assumptions about how students would commute. Factors such as the (preferred) mode of commuting or actual costs may vary from student to student. Moreover, the process of choosing an upper secondary programme to pursue is much more complex and multifaceted. The preference for entering school-based education at the upper secondary level is contrasted with that of the vast and heterogeneous vocational education sector. Despite some empirical evidence on the generally higher returns to education when completing school-based programmes and attaining higher education entry certificates (Falcon 2020; Korber and Oesch 2019), entering vocational education and training is by no means a necessarily less attractive choice, particularly when taking occupational interests and attitudes towards school into account (Basler et al. 2021; Jüttler et al. 2021). Moreover, the data do not allow investigation of whether students living distant from the nearest upper secondary school actually tend to select into educational alternatives offered nearby. Limiting students' choice sets and instead focusing on different types of school-based education offered at different locations, such as specialisations or main subjects (Denzler and Wolter 2010), appears to be a fruitful study design for future research.

Third, while the COFO data provide a large nationally representative sample of students in Switzerland along with an extensive survey, the specific institutional circumstances within cantons (Combet 2019; Leemann et al. 2022) or opportunity structures within municipalities remain largely obfuscated. Future research is encouraged to investigate the role of geographical constraints on upper secondary track choice on a regional scale, for instance, by drawing entirely on administrative data. Particularly in countries with a federalist organisation of education, such as the case of Switzerland portrayed here, analyses on a subnational level would allow to keep the institutional circumstances largely constant and to map the local opportunity structures in a more comprehensive way (Kuhn 2022; Sixt et al. 2018).

The present study suggests that structural features of space matter for students' educational choices, notably above and beyond their school-related and sociodemographic characteristics. By replicating the finding from research on higher education that large distances to educational institutions may constrain the scope of feasible educational alternatives, this study contributes to the somewhat mixed evidence on secondary education (Dickerson and McIntosh 2013; Dollmann and Weißmann 2022; Falch et al. 2013; Sixt et al. 2018). It is important to recall that Switzerland is a comparatively small country with an exceptionally well-developed public transportation infrastructure. Against this backdrop, it is not implausible that the negative association with distance is more pronounced in other country contexts. Nevertheless, also the Swiss data point to a non-negligible number of students living in "education deserts" (Hillman 2016; Lee and Pirog 2023), where upper secondary schools cannot be easily reached by commuting. Although the overall scope for pol-

icy to reduce educational inequalities by increasing the geographical accessibility of upper secondary schools may be limited or disproportionate to costs, policymakers are urged to ensure equal access to education for those living in remote regions. In light of residential sorting and segregation, it cannot be regarded as random where students with given social background characteristics live. Still, there is an element of chance involved in why certain students would need to commute 15 min and others 30 min to reach the nearest school. Thus, the present study implies that the educational pathways students pursue are, to some extent, also an expression of chance. Many aspects of the role of geography and spatial features for educational behaviour remain to be understood. Therefore, future research is encouraged to delve deeper into the geography of educational opportunity.

Supplementary Information The online version of this article (https://doi.org/10.1007/s10037-025-00249-9) contains supplementary material, which is available to authorized users.

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Data availability The Scientific Use Files of the Checks are available free of charge on SWISSUbase (DOI: https://doi.org/10.23662/FORS-DS-1004-1) Due to data protection regulations, the linked administrative data used for analysis cannot be made available. However, the description included in the replication package on OSF (https://osf.io/qt347/) mentions the number of the data linkage agreement used for this study, which interested researchers can use to order the identical data from the Federal Statistical Office.

Conflict of interest R. Benz declares that he/she has no competing interests.

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