Published in "Oxford Economic Papers, 72:2, 347-369, 2019" which should be cited to refer to this work.

Sociocultural background and choice of STEM majors at university

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Abstract

This article proposes a generalized Roy model to examine the role of students' sociocultural background for choosing a STEM major at university. We combine survey data on Swiss university graduates with rich municipality level information. We use a principal component analysis to construct an indicator capturing progressive attitudes in a student's home environment. Our structural approach allows directly comparing the importance of sociocultural background with that of pecuniary returns and costs in the choice of college major. Identification exploits individual differences in the relative cost of studying STEM that are unrelated to the local economic environment. Male students from conservative backgrounds are more likely to study STEM, whereas women are unaffected by sociocultural background besides majority language. The effect of the progressivism indicator for males is about half of the effect of the earnings return to STEM and twice as large as the effect of the relative monetary cost.

JEL classifications: I20, C31.

1. Introduction

Technological progress relies on innovations that are created by scientists and engineers. There is consequently a widespread consensus that the so-called *STEM* (science, technology, engineering, and mathematics) skills are of major importance to sustain innovation and growth.[1] Yet, the average share of new university entrants into STEM fields in OECD

1 See Hunt and Gauthier-Loiselle (2010) and Winters (2014), who present evidence for large human capital externalities of STEM graduates, e.g. in the form of patents.

countries in the year 2011 was only about 25%, where 39% of male students and 14% of female students choose a STEM field (OECD, 2013, Table C3.3b). These figures cause concern to policymakers and employers who perceive a lack of qualified candidates for jobs requiring STEM skills.

Akerlof and Kranton (2000, 2002) point out that the social setting may be an important driver of educational choices. They propose a human capital model that incorporates social incentives in addition to the usual economic returns and constraints. Macroeconomic evidence highlights the role of cultural factors for economic growth (e.g. Guiso *et al.*, 2006; Tabellini, 2008; Becker and Woessmann, 2009). However, the relevance of the sociocultural setting for microeconomic outcomes has proven difficult to establish empirically.

This article sets out to explore to what extent the decision to study a STEM field is influenced by the sociocultural background of a student at the micro level, combining unique survey data on the population of university graduates in Switzerland with rich municipality level information. We exploit the important differences in social and cultural norms and attitudes in the about 2,600 municipalities, while economically Switzerland is highly integrated. We construct an indicator capturing progressive attitudes in a student's home environment from a principal component analysis that is based on referenda results about gender- and science-related progressive issues, parliamentary election results, and the share of Catholics in the municipality a high school graduate resided in before entering university.[2]

At first glance, one may think that a progressive environment contributes to developing a taste for science. Alternatively, however, STEM fields may be preferred in conservative environments vis-à-vis, for instance, social sciences which may be viewed as being oriented to liberal political attitudes. One may also hypothesize that conservatism is related to a low fraction of females choosing a STEM field by creating an environment in which certain fields and occupations are perceived as being better suited for either males or females.

We derive a structural estimation framework from a generalized Roy model (Roy, 1951; Heckman and Vytlacil, 2007) that accounts for differences in both pecuniary and subjective benefits and costs of studying a STEM major rather than other university majors. Our approach allows us to directly compare the importance of sociocultural background with the pecuniary returns and costs in the choice of college major. When students make their choice they evaluate the return of a STEM major relative to a non-STEM major in terms of earnings as well as the cost differential between the two. Since we observe earnings associated with a particular major only for the group of people who self-select into the major, we have to estimate the conditional expectation functions of earnings associated with STEM and non-STEM majors by correcting for selection bias in order to construct the pecuniary return to STEM majors.

At the time of our study all Swiss inhabitants graduating from general high school could freely choose which field and at which Swiss university to study irrespective of prior specializations. Study fees are rather low in international comparison. They are similar across universities and the same for all majors within a university. The main driver of pecuniary costs is the geographic proximity of a student's home municipality to the next technical

2 In Switzerland, Catholics typically are associated with more conservative religious values compared to Protestants, which has been attributed to the Reformation process in Switzerland itself (e.g. Gordon, 2002). The share of Catholics indeed enters negatively in our progressivism indicator.

university (exclusively specializing in STEM fields and enjoying high reputation) relative to the next standard university. Thus, we exploit that the *relative* geographic proximity of a technical university affects the selection into majors. We argue that, controlling for local economic conditions in the region a university graduate resided in before entering university, relative distance to the next technical university is unrelated to their earnings capability, thus serving as an exclusion restriction. In extensive sensitivity analyses, we verify that our identification strategy proves robust to modifications of our benchmark model.

The empirical analysis focuses on Swiss university graduates who finished their studies in the early 2000s and for which we observe earnings five years after graduation, parental education, age, gender, and the home municipality in which they lived at the end of high school. To measure a respondent's sociocultural environment at the municipality level in a way that is not contaminated by social desirability considerations, we take advantage of the unique direct democratic system in Switzerland. In addition to the fraction of votes that accrued to left-wing parties at the national parliamentary elections in 1995 and religious denomination, our indicator of progressivism in a municipality is constructed from the results of four national referenda on introducing equal rights of men and women in the constitution (referendum held in 1981), on providing addicts with medical prescriptions of heroin (1999), on allowing stem cell research (2004), and on the civil union of homosexual couples (2005), providing similar rights than to married couples. Further, we capture the sociocultural environment by the majority language in a municipality.

Our main results are as follows. First, students from more progressive municipalities are significantly less likely to study a STEM field at university. Regressions with gender interactions suggest further, that the sociocultural environment affects especially the behaviour of young men. An increase in the progressivism indicator by one standard deviation reduces the probability to choose a STEM major at university by 3.9 percentage points (around 13%), according to our benchmark model. In absolute terms, its magnitude is about half of the effect of the earnings differential between STEM and non-STEM graduates and twice as large as the effect of relative distance to the next technical university. In contrast, a progressive environment does not affect the probability to study a STEM major for women. In the majority language dimension, sociocultural background matters for women as well. Moreover, while the pecuniary return to STEM majors plays a large role for men, our evidence suggests that it does not affect the probability to study STEM among women.

The main innovation of our approach is to capture social incentives as reflected in the sociocultural background of a student. Previous studies on college major choice focused on the role of quantitative abilities (e.g. Arcidiacono, 2004; Wang, 2013; Stinebrickner and Stinebrickner, 2014), specialization in high school (Card and Payne, 2017), parental background (e.g. Boudarbat and Montmarquette, 2009; Sonnert, 2009), expected future labour force participation (e.g. Polachek, 1978; Blakemore and Low, 1984), expected lifetime earnings (e.g. Berger, 1988; Eide and Waehrer, 1998; Boudarbat, 2008; Arcidiacono *et al.*, 2012; Wiswall and Zafar, 2015) as well as tastes and social orientation of an individual (Humlum *et al.*, 2012; Wiswall and Zafar, 2015). Our article contributes to this literature by employing a unique data set to examine the role of objective measures for the sociocultural environment for individual tastes based on a structural model. Addressing the gender gap in STEM field choice, Carrell *et al.* (2010) find that the gender of the professor plays a role for both females' performance in basic math and science classes and the choice of women with high quantitative skills to graduate from a STEM field. Card and Payne (2017) document that the course orientation in high school is important for the gender gap.

Finally, Montmarquette *et al.* (2002) and Zafar (2013) that earnings are a more important determinant of major choice for men than for women. Our results are consistent with the latter finding and generally evaluate the impact of the relative return and costs to study STEM for men and women separately.

The article is organized as follows. In Section 2, we sketch the theoretical background and the empirical strategy. Section 3 describes the institutional setup and data. Section 4 discusses the empirical implementation. Section 5 presents the estimation results. The last section concludes. The Online Appendix contains further details on the theoretical and empirical framework as well as a large body of additional empirical evidence.

2. Framework

We now sketch the generalized Roy model that we estimate.[3] We focus on the binary decision to study a STEM field (alternative 1) or a non-STEM field (alternative 0). According to the model individuals evaluate the benefits and costs over the life cycle associated with the choice of a particular major at university. Individuals select the major that yields the higher net benefit for them. In addition to monetary benefits and costs we also introduce net subjective costs that stem from a perceived subjective distance between the own sociocultural background and the values typically associated with a university major.

The monetary return to STEM-fields is not observable to an econometrician because earnings are only observed for the field actually chosen. The econometrician therefore has to take into account the self-selection of individuals into study fields according to their individual comparative advantage. To identify the conditional expectation functions of earnings associated with STEM and non-STEM fields free of selection bias we rely on a multistage estimation procedure and exclusion restrictions.[4]

Specifically, the estimation proceeds as follows. Let $\mathbf{x}_i$ be a row vector of variables that influence earnings capability of an individual i and denote by $\mathbf{z}_i$ a row vector of individual characteristics that influence tastes for a university major, reflecting monetary and net subjective costs of the majors. Also define $\mathbf{w}_i \equiv (1, \mathbf{x}_i, \mathbf{z}_i)$. At stage 1, we estimate:

$$\Pr\{s_i = 1|\mathbf{w}_i\} = \Pr\{\mathbf{w}_i\pi \geq \varepsilon_i|\mathbf{w}_i\} = \Phi(\mathbf{w}_i\pi), \tag{1}$$

where s_i is an indicator function equal to one when utility from choosing a STEM field is at least as high as utility when choosing a non-STEM field, $\boldsymbol{\pi}$ is a column vector of coefficients, and ε_i is the error term. For practical purposes, we assume the error term to be standard normally distributed, i.e. $\varepsilon_i|\mathbf{w}_i \sim \mathcal{N}(0,1)$.[5] Φ thus denotes the standard normal c.d.f.; its p.d.f. is denoted by φ.

3 For details of the model that gives rise to a structural binary choice model and the empirical identification strategy, see Online Appendix.

4 See for example, the seminal work by Heckman (1976, 1979) and Willis and Rosen (1979) in the context of college attendance. French and Taber (2011) and Heckman *et al.* (2006) provide an illuminating survey.

5 Normality of ε_i and the linear index structure in (1) as well as the linearity assumptions in (2) and (3) are not needed for econometric identification since we also rely on exclusion restrictions. From a practical perspective, a flexible parametric specification that exploits exclusion restrictions seems a good compromise. The Online Appendix shows that we can alternatively relax normality and obtain similar estimation results.

Suppose that earnings y_{ij} (observed at some point of the career) of individual i when choosing major $j \in \{0, 1\}$ are in the same way for both majors proportional to the present discounted value of the earnings stream. y_{ij} is given by some major-specific function f_j, which depends on the observable characteristics $\mathbf{x}_i$ and an individual- and major-specific ability component, u_{ij}, that is unobservable for an econometrician; that is, $y_{ij} = f_j(\mathbf{x}_i, u_{ij})$. We assume a familiar linear form for log earnings of an individual such that:

$$\ln y_{ij} = \beta_{0j} + \mathbf{x}_i\beta_j + u_{ij},\ j \in \{0, 1\}. \tag{2}$$

where β_{0j} is an intercept and β_j is a vector of slope parameters. Further, express the rela-tionship between the error terms u_{ij} in wage eq. (2) and ε_i as:

$$u_{ij} = \gamma_j\varepsilon_i + \zeta_{ij}, \tag{3}$$

with expectation $\mathrm{E}[u_{ij}|\mathbf{w}_i, \varepsilon_i] = \gamma_j\varepsilon_i$, which implies that $\mathrm{E}[\zeta_{ij}|\mathbf{w}_i, \varepsilon_i] = 0$ and $\gamma_j = \mathrm{Cov}(u_{ij}, \varepsilon_i)$ is the covariance of u_{ij} and ε_i. To account for selection bias, at stage 2 we then estimate wage regressions:

$$\ln y_{i0} = \beta_{00} + \mathbf{x}_i\beta_0 + \gamma_0\lambda_{i0} + \eta_{i0}, \tag{4}$$

$$\ln y_{i1} = \beta_{01} + \mathbf{x}_i\beta_1 + \gamma_1\lambda_{i1} + \eta_{i1}, \tag{5}$$

where:

$$\lambda_{i0} \equiv \frac{\varphi(\mathbf{w}_i\pi)}{1 - \Phi(\mathbf{w}_i\pi)},\ \ \lambda_{i1} \equiv -\frac{\varphi(\mathbf{w}_i\pi)}{\Phi(\mathbf{w}_i\boldsymbol{\pi})}, \tag{6}$$

denote inverse Mills ratios and we define error term $\eta_{ij} \equiv \gamma_j(\varepsilon_i - \lambda_{ij}) + \zeta_{ij}$, $j \in \{0, 1\}$, in the subsamples for which wages associated with alternatives 1 and 0, respectively, are observed. The greater $-\varepsilon_i$ the greater the unobserved relative advantage for STEM fields. Hence, if the estimate of $\gamma_1 = \mathrm{Cov}(u_{i1}, \varepsilon_i)$ is negative, the unobserved relative advantage for STEM, $-\varepsilon_i$, and the unobserved earnings capability u_{i1} are positively related, such that that mean earnings associated with a STEM field are higher in the subgroup of people who have chosen that major than in the total population of college graduates. The opposite holds if the estimate of γ_1 is positive. If $\gamma_0 = \mathrm{Cov}(u_{i0}, \varepsilon_i)$ is positive (negative), there is positive (negative) selection of non-STEM graduates.

In practice, λ_{i0} and λ_{i1} are unknown. We obtain estimates $\hat{\lambda}_{i1}$ and $\hat{\lambda}_{i0}$ by evaluating the right-hand sides of (6) using the estimated coefficients $\hat{\boldsymbol{\pi}}$ from the first stage probit regression (1). As shown by Heckman (1976, 1979), the two-step estimation procedure yields consistent estimates $(\hat{\beta}_{00}, \hat{\beta}_0)$ and $(\hat{\beta}_{01}, \hat{\beta}_1)$ for coefficient vectors (β_{00}, β_0) and (β_{01}, β_1). The conventional OLS standard errors for the estimated coefficients in (4) and (5) are incorrect, however, when $\gamma_j \neq 0$, $j \in \{0, 1\}$, because the conditional variances of the error terms, $\mathrm{Var}(\eta_{i0}|\mathbf{w}_i, s_i = 0)$, $\mathrm{Var}(\eta_{i1}|\mathbf{w}_i, s_i = 1)$, are nonconstant and $\hat{\lambda}_{i0}$, $\hat{\lambda}_{i1}$ are generated regressors. Therefore, we bootstrap the full three-step estimation procedure using 499 bootstrap replications. Specifically, we apply the weighted bootstrap suggested by Barbe and Bertail (1995). For each person in our data set we generate 499 weights based on random draws from a gamma distribution with shape and scale parameters equal to one. Thus, the bootstrap weights are non-integer and the probability that a weight exactly equals zero is zero. With a binary dependent variable and a number of discrete regressors, this bootstrap procedure has the advantage that we avoid having to repeat the sampling if, in a given resample, the maximum likelihood estimation fails to converge or certain covariate settings perfectly predict the dependent variable (see also Fitzenberger and Muehler, 2015, for a similar argument).

In the final stage 3 (structural major choice), we estimate the structural choice equation:

$$\Pr\left\{s_i = 1|\mathbf{x}_i, \mathbf{z}_i\right\} = \Pr\{\delta_0 + \alpha[\hat{\beta}_{01} - \hat{\beta}_{00} + \mathbf{x}_i(\hat{\beta}_1 - \hat{\beta}_0)] + \mathbf{z}_i\delta \geq \varepsilon_i|\mathbf{x}_i, \mathbf{z}_i\right\}, \quad (7)$$

where α is the coefficient on the estimated expected log wage differential between STEM and non-STEM fields, $\hat{\beta}_{01} - \hat{\beta}_{00} + \mathbf{x}_i(\hat{\beta}_1 - \hat{\beta}_0)$, δ is the vector of coefficients on taste characteristics, and δ_0 is a constant. Again, we rely on the bootstrap procedure described above to obtain standard errors that are valid when the generated wage difference is included as regressor.

As discussed in detail in the coming section, we think of the taste characteristics in $\mathbf{z}_i$ that are not included in $\mathbf{x}_i$ as the distance of the students' home municipality to the next technical university relative to the next cantonal university, and the sociocultural environment (progressivism and majority language) in the home municipality at the time the major is chosen. Both $\mathbf{x}_i$ and $\mathbf{z}_i$ include dummies for the broader region a student lives in before entering university as well as, in sensitivity analyses, other variables capturing the economic background that may be correlated with unobserved earnings capability of students. Technical universities specialize in STEM fields whereas the cantonal universities offer only a limited range of less prestigious STEM programmes. Thus, relative distance to the next technical university is a prime candidate for an excluded variable in the earnings regressions to capture the variation of relative costs to study a STEM field within regions. We will show that it is unrelated to the earnings differential across the two alternatives and, on average, different for STEM and non-STEM graduates.

3. Background and data

3.1 Institutional background

Like Germany, Switzerland is well known for a strong vocational training system. In 2000, around the time we observe the university graduates in our data, 90% of the Swiss population aged 25–34 held at least an upper secondary degree, a figure that has remained stable thereafter (OECD, 2017, Table A1.2). Attending a Swiss university requires an upper secondary degree from a general high school (*Gymnasiale Matura*), which is obtained by about 20% of a cohort (Federal Statistical Office, 2015). In 2002, the share of graduates from tertiary-type A programmes to the population of the typical age group was 17.9% of a cohort (OECD, 2004, Table A3.1). The figure is comparable to Germany (19.2%), Austria (18%) and France (24.2%). At the time of our study, individuals with a *Gymnasiale Matura* degree—irrespective of the chosen specialization in secondary school—could choose freely among the available programmes at all universities in Switzerland, without university entrance exams, restrictions in terms of minimum high school grade point average, or other selection procedures.[6] Tuition fees in Swiss universities are

6 Only medical schools began, in the year 1998, to select students according to their grade point average at high school and in an entrance exam. These restrictions are not relevant for the cohorts in our data set.

moderate in international comparison, both in absolute terms and relative to housing costs. They are similar across universities and the same for all majors within a university.

In the 1990s and early 2000s, around 75% of the young people with a Swiss general high school degree enrolled at a university within a year after high school graduation (Federal Statistical Office, 2013). There was no distinction between undergraduate and graduate university degrees. Graduating from university meant completing a curriculum comparable to a master's degree in Switzerland and other advanced countries nowadays.[7]

In the period under study, there were eleven universities in Switzerland, all of which are publicly funded and managed. The two technical universities, called *Eidgenössische Technische Hochschulen* (ETH), are the only federal universities in Switzerland. They are located in the cities of Lausanne and Zurich. At the time of our research they offered programmes in the STEM fields physical sciences, chemistry, biology, geography, geology, mathematics, computing, and technical sciences (primarily engineering). No other fields were offered. All other universities are governed at the cantonal (i.e. state) level. The nine cantonal universities are located in the cities of Basel, Berne, Fribourg, Geneva, Lausanne, Lugano, Neuchâtel, St. Gallen, and Zurich. The cantonal universities offer degree programmes in both STEM and non-STEM fields. For STEM fields, however, the technical universities are better endowed, have much bigger departments and offer a wider variety of programmes and specializations than the cantonal universities. Thus, a STEM degree from a technical university is considered as somewhat more prestigious than one from a cantonal university.[8] In our data set, 62.8% of STEM university graduates attended one of the two technical universities.

Nationwide drop-out rates are similar across STEM and non-STEM programmes and relatively low in international comparison, suggesting a comparatively well informed selection of university students on average. Of those university students enrolled in a particular programme in the year 2001, for instance, 30.2% did not graduate from that programme within 10 years and the vast majority of them had definitely dropped out of it (Wolter *et al.*, 2014).[9]

There is a pronounced gender gap in choosing STEM fields in Switzerland, that is comparable to Germany, Austria, and France, for instance. According to OECD (2013, web Table C3.3b), in 2011, 35.1% of males in tertiary education are in STEM programmes (excluding life sciences), but only 8.1% of females. Respective figures are 44.6 vs 12.2% in Germany, 38.1 vs 10% in Austria, and 29.4 vs 13.8% in France.

7 In the mid-1990s, a second type of academic tertiary education institution, the Universities of Applied Sciences (*Fachhochschulen*), was established. They offered shorter, more practically oriented and occupation-specific programmes compared with those at universities. In 1999, 7% of a cohort obtained an upper secondary degree from a vocational high school (*Berufsmatura*) that prepares for study of a particular field at a University of Applied Sciences. High school graduates with a *Gymnasiale Matura* degree but no job experience are not entitled to enrol.

8 For instance, Nobel Prize winner Albert Einstein studied between 1896 and 1900 at the ETH Zurich where he later also served as professor. Until today, 21 Nobel prize winners have studied or worked at the ETH Zurich. However, doctoral degrees can be obtained and are equally common at both types of universities.

9 The drop-out patterns are very different from those reported by Arcidiacono (2004) and Stinebrickner and Stinebrickner (2014) for the USA. Their evidence suggests that an extraordinarily high fraction of students, who intend to or actually start a science major, graduate in another major or drop out of university.

3.2 Graduate survey

Our main data source is the 'Swiss Graduate Survey' of the Federal Statistical Office, a unique survey of the full population of graduates from tertiary academic education in Switzerland. We consider all Swiss respondents who lived in Switzerland when graduating from high school and graduated in 2000 and 2002 from one of the nine cantonal or the two federal universities. All graduates of these two cohorts received a questionnaire one year after graduation. All respondents in the first wave received a follow-up questionnaire five years after graduation. Participation in the survey was voluntary. The response rate was about 60% in the first wave. 65% of those who responded in the first wave responded in the second wave. We use the probability weights provided by the Federal Statistical Office to account for potentially selective nonresponse.

The survey contains a large array of individual characteristics including earnings, hours worked, major at university, gender, specializations in general high school, the level of education of mother and father, as well as the home municipality before entering university. To construct our main dependent variable, we categorize graduates into two groups according to their field of study. We define STEM majors as those offered by the two federal technical universities in Switzerland. The remaining majors are classified as non-STEM or Humanities.

Since expected earnings differences between fields of study may have an important impact on study major choice, the availability of individual earnings several years after graduation is crucial for our estimation strategy. We therefore restrict the analysis sample to those who participate also in the second wave that includes information on earnings five years after graduation. We consider earnings in the main job including also overtime compensation and bonus payments. We divide total earnings by total hours worked (contractual hours plus overtime) to obtain the hourly wage rate we use in the estimations.

To focus on a typical career and mitigate potential measurement error, we focus on employed graduates without extreme or missing values of earnings, study duration, or age. There is little difference between those excluded because of extreme earning values according to gender or field. Graduates with extreme study duration or high graduation age are excluded since we want to focus on first-time graduates. Moreover, some individuals take advantage of the unrestricted university access and enroll without intention to base their career on the acquired education. Our data reveals that this is the case especially in social sciences, history & culture and literature, but much less so in STEM fields. In total, we drop 25.7% of the original sample. Our final sample includes 4,767 individuals.[10]

3.3 Geographical and sociocultural data

For our analysis, an important piece of information in the 'Swiss Graduate Survey' is the home municipality of each graduate at the end of high school. We draw on this variable to characterize a student's sociocultural background at the time of major choice. There are

10 In the Online Appendix, we show that the main results are robust to lifting the sample restrictions except that we still require an individual to be employed and have valid information on hours worked, and not to have extreme study duration. Keeping these two restrictions is necessary for our structural approach that requires estimating earnings regressions and focusing on persons who enroll at university with the intention to base their career on the acquired education. These are the ones we hypothesize to respond to the modelled incentives.

about 2,600 municipalities in Switzerland, which allows us to reconstruct the sociocultural environment at a very detailed regional level.

Most municipalities are small in terms of population size and area. Ninety-five per cent of the municipalities are smaller than 59.1 km^2 (22.8 mi^2) or have less than 11,000 inhabitants. In the 53 municipalities that are larger than 100 km^2, the average fraction of populated land is 1.5%, as most people live downtown.

First, we construct the driving distance from downtown of the home municipality to the next technical university (ETH) relative to the driving distance to the next cantonal university with the help of Google Maps. Second, we determine the majority language and the religious environment (share of Catholics) of a graduate's home municipality using information from the 'Federal Population Census' in 1990. Third, we calculate the total vote share which accrued to left-wing parties in the Swiss national election in 1995 based on municipality level election data. Fourth, we use the results from four nationwide referenda that were particularly salient in the public debate to capture how progressive views were on gender equality and science-related issues: on introducing equal rights of men and women in the constitution held in 1981, on providing drug addicts with medical prescriptions of heroin held in 1999, on allowing stem cell research held in 2004, and on a civil union of homosexual couples held in 2005. We consider the latter referendum to be science-related because a large body of publicly well-received research has severely questioned the argument typically put forward by the religiously conservative that homosexuality is 'unnatural'. Also the referendum on novel ways to cope with criminal activity of heroin addicts is an example of science-based changes in political attitudes. Details of these referenda and results are taken from Année Politique Suisse, a data set described in Linder *et al.* (2010).[11] We list and describe this source and the other employed administrative data sources ('Swiss Graduate Survey', 'Swiss Historical Municipality Register', 'Federal Population Census', 'Federal Elections') in the Online Appendix.

To extract the common information contained in the share of yes-votes of the four referenda on gender equality and science-related issues described above, the vote share of left-wing parties, and the share of Catholics, we do a principal component analysis with these six variables (see the Online Appendix). They all load particularly well on a single principal component, with positive scoring coefficients for the vote shares and a negative one for the share of Catholics. Notably, the latter is, in the Swiss context, associated with more conservative attitudes (Altermatt, 1979; Gordon, 2002). We thus interpret the first principal factor as an indicator for 'progressivism' of a municipality.[12]

3.4 Economic environment

To capture the economic environment, we control for the broader Swiss region a student has resided in when leaving high school. We follow the Federal Statistical Office that distinguishes seven medium sized (so-called *NUTS*-2) regions based on both geographic and economic criteria (see Online Appendix).

In sensitivity analyses we also use information from the 'Federal Population Census' in 1990 on municipality size as well as, for the total population and for females, the

11 Downloadable at www.swissvotes.ch, retrieved 19 December 2013.

12 To see whether sociocultural attitudes are constant over time we run a fixed effects regression of the share of Catholics and the five vote shares on municipality and year fixed effects. Reassuringly, the year fixed effects are insignificant, see the Online Appendix.

employment rate, the sectoral structure (employment shares in manufacturing, business services, agriculture, and construction), or, alternatively, the occupational structure among the high-skilled (employment shares in management occupations, technical occupations, and in a category summarizing health, education, research, and culture occupations). As Switzerland is highly economically integrated within *NUTS*-2 regions, we do not expect these indicators to play a role for the outcomes of interest.

4. Implementation

We now discuss how we implement the three stage estimation procedure, particularly how we distinguish between variables entering stage 2 (earnings) and stage 3 (structural major choice). Table 1 provides an overview of the different (sets of) variables used in the empirical analysis and shows for the benchmark model in which stages of the estimation they enter.

4.1 Variables affecting pecuniary gains

Recall that variables in $\mathbf{x}_i$ are those which affect the earnings capability $y_{ij} = f_j(\mathbf{x}_i, u_{ij})$ for major j of an individual i at some point of the professional career (observed five years after graduating from university). They enter the earnings equations at estimation stage 2. We control for the age (in logs) of an individual five years after graduating from university to capture work experience (variable 'log age'). Some older graduates may have gained work experience prior or during attending university, the latter possibly prolonging their study duration, to the benefit of higher earnings early in the career. We also account for the fact whether an individual has participated in a post-graduate education programme for a period of at least six months (variable 'postgraduate education'). We expect individuals who have participated in such a programme to earn significantly less early in the career than those who have not because, for a given age, they tend to have shorter work experience at the time of observation. Finally, we include mutually exclusive measures of parental education indicating whether father or mother have tertiary academic education, vocational education, or no such education (those with missing information are allocated to the latter category). In this way we account for a possible intergenerational transmission of cognitive

Table 1. Benchmark model and exclusion restrictions

Variable	Estimation Stage: Red. form Choice	Estimation Stage: Earnings	Estimation Stage: Structural Choice	Interpretation
Progressivism indicator	x		x	Net subjective cost
Female	x	x	x	
Log rel. dist. to techn. univ.	x		x	Monetary cost
Majority language	x		x	Net subjective cost
Log age	x	x		Earnings capability
Post-graduate education	x	x		Earnings capability
Parental education	x	x		Earnings capability
NUTS-2 region fixed effects	x	x	x	Economic environment

Note: The model includes in addition a cohort dummy at all stages.

ability. We expect the education of parents to be much less important for success in the labour market within the group of university graduates as compared to the whole population.

4.2 Variables affecting monetary and net subjective costs

Identification requires that we find convincing exclusion restrictions. That is, we need variables $\mathbf{z}_i$ that reflect monetary and net subjective costs of major choice but are distinct from variables in $\mathbf{x}_i$ that affect the earnings capability of a student i.

4.2.1 Relative distance to next technical university With nine university locations in a small country like Switzerland, but only two technical universities that exclusively offer STEM programmes and are located in the high-cost areas Zurich and Lausanne, we hypothesize that the distance from the home municipality to the next technical university relative to the distance to the next cantonal university is a major determinant of the economic cost to study a STEM major.[13] For instance, a high school graduate living at their parents' home in the municipality of Rorschach faces the trade-off between studying, say, economics at the nearby cantonal university in St. Gallen (16.2 km driving distance) or studying a STEM field at ETH Zurich which is six times farther away. Our main identifying assumption is that the *relative* distance to the next technical university does not, at the same time, affect earnings associated with a given major, conditional on the economic environment (as captured by the broader region in which the home municipality is located). We take the log of relative distance to the next technical university to capture that the marginal impact of an additional kilometer on major choice is decreasing with distance.

The unrestricted access of those holding a *Gymnasiale Matura* degree to university programmes together with the geographical distribution of technical and cantonal universities in Switzerland provide a unique source of variation in the cost determinants of university majors.

4.2.2 Sociocultural characteristics Our preferred specification also holds that variables capturing the sociocultural background of students affect the decision whether to study a STEM field but do not affect the earnings gain associated with studying a STEM field, given the economic environment. Most importantly for our main research question, we include in $\mathbf{z}_i$ the indicator for progressive attitudes in the home municipality of a college graduate before going to university derived from principal component analysis involving the share of yes-votes of the four referenda on gender equality and science-related issues described above, the vote share of left-wing parties, and the share of Catholics in a municipality. Although political attitudes and religious denomination may have been related to cognitive skills in the 19th century (Becker and Woessmann, 2009; Boppart *et al.*, 2013, 2014), they are unlikely to affect the contemporaneous earnings differential between studying a STEM and non-STEM field.

Moreover, in Switzerland, the motivation to study a STEM field may depend on the majority language (German, French, Italian) of an individual's home environment. For instance, the two technical universities in Switzerland offer programmes in German, French,

13 We assume that all individuals within a home municipality live downtown. This is innocuous since 98% of municipalities have a radius of about 5.7 km or less (see Online Appendix for further muni-cipality characteristics).

and English but not in Italian. Further, language may also be perceived as a cultural characteristic that affects tastes. We include dummy variables for French and Italian as majority language, i.e. German as majority language is the left-out category.[14]

4.3 Variables affecting both pecuniary gains and costs

All stages of the estimation contain a dummy for females (variable 'female'), a dummy indicating whether the individual first responded in the 2002 survey rather than in 2000, and region dummies indicating the broader Swiss region a student has resided in when leaving high school. Including region fixed effects that characterize the economic environment strengthens our exclusion restriction that the distance to the next technical university relative to the next cantonal university is not correlated with unobserved earnings ability of a student. In sensitivity analyses, we also control for municipality size and further economic characteristics like the employment rate of females and of the total population, the sectoral structure or, alternatively, the occupational structure of a municipality at all stages of the estimation.

4.4 Gender differences

In order to examine whether the sociocultural characteristics contribute to explaining gender differences with respect to choosing a STEM field in university, in an extension of our benchmark estimations in Section 5.2, Section 5.3 allows for interaction effects with gender (except for the variables entering all stages, i.e. region fixed effects and the cohort dummy). In particular, we investigate whether there are gender differences in the role of sociocultural characteristics for major choice. Moreover, we use this specification to check the well-known hypothesis that female students are less motivated by earnings than males by including an interaction effect at stage 3 between the (expected) earnings differential across fields and gender.

5. Results

5.1 Summary statistics

Table 2 provides summary statistics of the variables employed in the baseline estimations. Five years after graduation, the average age of the respondents is 31 years. About (1,438/4,767=) 30% of the graduates studied a STEM field. Among STEM field graduates, 23.7% were woman. About 53% of the respondents participated in post-graduate education (slightly more among non-STEM graduates). About three quarters of the parents have at least vocational education. Gross hourly wages in the main job are somewhat lower for STEM graduates.[15] *Inter alia*, this reflects the extraordinarily high wages in the Swiss financial industry.[16]

14 We subsume the very few observations from Rhaeto-Romansh speaking municipalities to the category Italian speaking. Inhabitants of these municipalities speak Italian at least as their second language, typically being bilingual. Also notably, graduates from a general high school with mother tongue Italian are typically fluent in German or French.

15 Hourly wages are CHF 34.52 ($\approx$ US$ 28.77) vs CHF 36.66 ($\approx$ US$ 30.55). (Exchange rates are for 2007, the year of earnings information of the second cohort of graduates; see https://data.oecd.org/conversion/exchange-rates.htm).

16 One may also keep in mind that, under positive externalities of STEM graduates, market earnings in STEM occupations are too low from a social point of view. Switzerland does not provide tax support for business R&D, for instance, that could internalize positive externalities from innovative activity.

Table 2. Descriptive statistics of core variables

	STEM (1)	Non-STEM (2)	t-Statistic (3)
Individual level variables			
Female (1 = yes, 0 = no)	0.237 (0.425)	0.516 (0.500)	−19.709
Second cohort (1 = yes, 0 = no)	0.451 (0.498)	0.433 (0.496)	1.152
Age	30.89 (1.557)	31.11 (1.959)	−4.209
Log age	3.429 (0.050)	3.436 (0.062)	−3.850
Postgraduate education (1 = yes, 0 = no)	0.493 (0.500)	0.550 (0.498)	−3.601
Both parents with no/missing educ.	0.062 (0.241)	0.082 (0.274)	−2.532
F: no/missing, M: vocational educ.	0.033 (0.180)	0.042 (0.200)	−1.403
F: no/missing, M: university educ.	0.002 (0.045)	0.004 (0.065)	−1.331
F: vocational, M: no/missing educ.	0.107 (0.309)	0.116 (0.320)	−0.925
Both parents with vocational educ.	0.450 (0.498)	0.365 (0.481)	5.502
F: vocational, M: university educ.	0.015 (0.123)	0.025 (0.155)	−2.176
F: university, M: no/missing educ.	0.049 (0.216)	0.051 (0.219)	−0.262
F: university, M: vocational educ.	0.190 (0.392)	0.195 (0.396)	−0.415
Both parents with university educ.	0.092 (0.289)	0.122 (0.327)	−3.145
Gross hourly wage	34.52 (14.82)	36.66 (13.35)	−4.731
Log gross hourly wage	3.459 (0.414)	3.544 (0.343)	−6.833
Municipality level variables			
Distance to next university (km)	30.82 (30.25)	26.70 (30.37)	4.319
Distance to next ETH (km)	70.49 (49.92)	70.57 (49.48)	−0.050
Relative distance to ETH	11.65 (27.70)	15.81 (30.81)	−4.598
Log relative distance to ETH	1.058 (1.428)	1.342 (1.584)	−6.101
Share in favour of gender equality	0.610 (0.126)	0.645 (0.129)	−8.693
Share in favour of heroin programme	0.547 (0.101)	0.545 (0.104)	0.715
Share in favour of stem cell engineering	0.676 (0.097)	0.702 (0.102)	−8.594
Share in favour of gay marriage	0.591 (0.086)	0.596 (0.085)	−2.027
Share of left-wing parties	0.307 (0.125)	0.335 (0.133)	−6.873
Share of Catholics	0.502 (0.242)	0.490 (0.227)	1.609
Majority French (1 = yes, 0 = no)	0.257 (0.437)	0.374 (0.484)	−8.223
Majority Italian (1 = yes, 0 = no)	0.061 (0.240)	0.058 (0.234)	0.426
Observations	1,438	3,329	

Note: The first two columns show the means and standard deviations (in parentheses) of the variables, the last column the *t*-statistics of a test of equality of means.
Source: Author's calculations using Federal Statistical Office of Switzerland, Année Politique Suisse.

The average distance of the home municipality of graduates before entering university to the next technical university (ETH) is 71 km, whereas the average distance to the next cantonal university is about 28 km. While average distances to the next ETH do not differ between STEM and non-STEM graduates, STEM graduates live on average about 4 km farther away from the next cantonal university. This is an indication that the distance to the next ETH relative to the next cantonal university is an important cost component affecting university major choice. The average relative distance to the next ETH is significantly smaller for STEM than for non-STEM graduates (11.7 vs 15.8).

We also see significant differences between STEM and non-STEM graduates in their sociocultural environment. For instance, in home municipalities of STEM graduates, the share of yes votes in the referenda on gender equality and stem cell engineering are lower whereas the share of votes in favour of left-wing parties and the share of Catholics are higher, on average.

5.2 Benchmark model estimations

Table 3 presents the estimation results of all three stages for the benchmark model. Results from the reduced-form (stage 1) and structural choice estimations (stage 3) are shown in column (1) and (4), respectively. They correspond to average partial effects on the probability to choose a STEM field for one-standard-deviation changes of continuous regressors (the progressivism indicator, log relative distance to the next technical university, log age five years after graduation, and the predicted log wage differential between STEM and non-STEM fields) and to discrete changes in the response probability for dummy regressors. First, an increase in the progressivism indicator by one standard deviation lowers the likelihood to study a STEM field by 2.3 percentage points, according to the structural choice estimation. The effect is similar to the reduced-form estimation and statistically different from zero at the 1% level. Second, as expected from the summary statistics, women are significantly less likely to study a STEM field. Our structural estimation predicts that the probability for females to graduate in a STEM field is 9.8 percentage points lower than for men. This mirrors the widely-discussed substantial gender differences in university major choice we see in most OECD countries, including Switzerland. Third, and important for our identification strategy, an increase in the log relative distance to the next technical university significantly reduces the probability of choosing a STEM major. The effect size of 2.2 percentage points (column [4]) is comparable to that of an increase in the progressivism indicator. Fourth, students with a Francophone background are less likely to choose a STEM field than students with a home municipality where German or Italian is the majority language. This result does not only underline the importance to control for language effects in the Swiss context, but also suggests that cultural background may matter for important choices.[17]

Results of the earnings regressions (stage 2) for STEM and non-STEM fields are given in column (2) and (3) of Table 3, respectively. In columns (2) and (3), the partial effect of log age is also scaled to reflect a change by one standard deviation. For the other variables in the earnings regressions, we show the partial effects of unit changes (dummy variables and estimates of correction terms [6]). We find that the estimated coefficients for the correction terms $\hat{\lambda}_{i1}$ and $\hat{\lambda}_{i0}$ are both positive albeit only for non-STEM graduates significantly different from zero when tested individually (at the 1% level). A joint Wald test suggests that they are significantly different from zero (p-value is 0.006). The positive sign of the coefficient for non-STEM graduates suggests that they are positively selected. Individuals with high unobserved earnings capability for non-STEM fields may select into fields like economics, management or law because of extraordinarily high wages in the (quantitatively important) Swiss financial industry. This demonstrates the importance of accounting for potential selection bias for our general research question using Swiss data.

17 Eugster *et al.* (2017) and Steinhauer (2018) also make use of the cultural diversity in Switzerland to study how majority language affects unemployment and labour force participation of mothers, respectively.

Table 3. Benchmark estimations

	Reduced Form STEM Choice (1)	Log Wage STEM (2)	Log Wage Non-STEM (3)	Structural STEM Choice (4)
Average partial effects and standard errors				
Progressivism indicator	−0.024			−0.023
	(0.007)***			(0.007)***
Female	−0.124	−0.029	0.022	−0.098
	(0.008)***	(0.032)	(0.021)	(0.018)***
Log relative distance	−0.018			−0.022
	(0.009)**			(0.009)**
Majority French	−0.038			−0.027
	(0.012)***			(0.013)**
Majority Italian	0.012			0.010
	(0.028)			(0.029)
Log age	−0.058	−0.002	0.033	
	(0.007)***	(0.020)	(0.011)***	
Postgraduate education	−0.030	−0.111	−0.027	
	(0.007)***	(0.013)***	(0.009)***	
F: no/missing, M: vocational educ.	0.005	−0.022	−0.000	
	(0.008)	(0.015)	(0.007)	
F: no/missing, M: university educ.	−0.001	−0.031	0.010	
	(0.007)	(0.007)***	(0.005)**	
F: vocational, M: no/missing educ.	0.013	−0.002	0.005	
	(0.010)	(0.016)	(0.010)	
Both parents with vocational educ.	0.043	−0.009	−0.008	
	(0.012)***	(0.025)	(0.015)	
F: vocational, M: university educ.	−0.004	0.005	−0.006	
	(0.008)	(0.015)	(0.008)	
F: university, M: no/missing educ.	0.014	−0.012	0.002	
	(0.008)*	(0.013)	(0.009)	
F: university, M: vocational educ.	0.021	−0.017	−0.004	
	(0.011)*	(0.019)	(0.012)	
Both parents with university educ.	0.011	−0.044	−0.025	
	(0.010)	(0.017)**	(0.011)**	
Correction term λ		0.074	0.384	
		(0.109)	(0.122)***	
Log wage differential				0.048
				(0.014)***
Model statistics				
Observations	4,767	1,438	3,329	4,767
(Pseudo) R^2	0.09	0.14	0.07	0.08

Note: In columns (1) and (4), the dependent variable is a dummy for graduation in a STEM field. In columns (2) and (3), the dependent variable is the log hourly wage of STEM and non-STEM graduates, respectively. Columns (1) to (4) show the average partial effect of the corresponding regressor for a regressor change by one standard deviation (continuous regressors, except correction terms) or from zero to one (dummy regressors). The model includes in addition *NUTS*-2 region fixed effects and a cohort dummy at all stages. Bootstrapped standard errors are shown in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.
Source: Author's calculations using Federal Statistical Office of Switzerland, Année Politique Suisse.

The coefficients on the female dummy in both earnings regressions are insignificant after conditioning on observed characteristics and the correction terms for self-selection.[18] Moreover, older and more experienced non-STEM graduates have higher earnings. An increase in the age five years after graduation from 32 to 34 would raise earnings by 3.3%.[19] The wage effect of an increase in log age is insignificant, however, for STEM graduates.

As expected, individuals with post-graduate education earn significantly less five years after graduation, particularly STEM graduates. Interestingly, earnings do not systematically increase with the education level of parents. This is not implausible. The education of parents would certainly matter for earnings in a sample with both graduates and non-graduates but there is not much reason for such an effect when restricting focus on those who attend university. Furthermore, a Wald test rejects the hypothesis that the coefficients on the earnings determinants $\mathbf{x}_i$ are equal between STEM and non-STEM graduates (p-value is 0). Thus, the expected return to STEM fields is statistically different from zero.

The key difference between third stage estimates in column (4) and those in column (1) is that at stage 3 we employ the estimated expected log wage differential across fields (see eq. [7]) rather than the variables that affect earnings capability. A change in the log wage differential by one standard deviation increases, on average, the fraction of STEM major graduates by 4.8 percentage points. The average partial effect is highly significant. Comparing the effect size (of a one-standard-deviation change) to that of the progressivism indicator and relative distance to the next technical university suggests that the role of the sociocultural background for university major choice is substantial compared with standard economic determinants. For instance, the absolute magnitude of the effect of progressivism is about half the effect of earnings and somewhat larger than the effect of relative distance to the next technical university.

To check empirical relevance of our exclusion restrictions, we conduct Wald tests on the coefficient estimates in the reduced form model (see the Online Appendix). Specifically, we test individual and joint significance of the regressors grouped according to the categories in Table 1. Supporting our identification strategy, the coefficient on the monetary cost indicator (log relative distance to the next technical university, excluded from stage 2) is significantly different from zero at the 5% level. The coefficients on the sociocultural variables (progressivism and majority language, excluded from stage 2) are jointly significant at the 1% level. The same is true for the variables affecting earnings capability (log age, dummies for postgraduate training and parental education, excluded from stage 3). Coefficients on region fixed effects have a p-value of 12% in a joint test.

5.3 Interactions across gender

We now examine gender-specific effects of sociocultural characteristics and pecuniary incentives for university major choice. Table 4 presents the results analogous to Table 3, with effects separated for men and women. They are based on an estimation with gender interactions with coefficients shown in the Online Appendix.

The quantitative effects of relative distance to the next technical university and majority language are similar to those presented in Table 3 for both genders. The coefficients on the

18 Without correcting for self-selection, we find that female STEM (non-STEM) graduates earn 10% (8.1%) less than their male counterparts (see Online Appendix).

19 According to Table 2, one standard deviation of log age for non-STEM graduates is 6.2%. Evaluated at age 32, these are two years. The average partial effect of log age in column (3) of Table 3 is 0.033.

Table 4. Estimations with gender interactions

	Reduced Form STEM Choice (1)	Log Wage STEM (2)	Log Wage Non-STEM (3)	Structural STEM Choice (4)
Average partial effects for men				
Progressivism indicator	−0.042			−0.039
	(0.011)***			(0.011)***
Log relative distance	−0.021			−0.023
	(0.012)*			(0.013)*
Majority French	−0.036			−0.024
	(0.016)**			(0.016)
Majority Italian	0.014			0.011
	(0.034)			(0.035)
Log age	−0.081	−0.001	0.033	
	(0.011)***	(0.022)	(0.016)**	
Postgraduate education	−0.048	−0.108	−0.030	
	(0.011)***	(0.015)***	(0.013)**	
F: no/missing, M: vocational educ.	0.001	−0.017	−0.000	
	(0.011)	(0.015)	(0.010)	
F: no/missing, M: university educ.	0.008	−0.038	0.007	
	(0.013)	(0.005)***	(0.009)	
F: vocational, M: no/missing educ.	0.021	0.004	0.006	
	(0.014)	(0.019)	(0.013)	
Both parents with vocational educ.	0.065	−0.009	−0.006	
	(0.017)***	(0.028)	(0.020)	
F: vocational, M: university educ.	0.003	0.001	−0.008	
	(0.011)	(0.016)	(0.010)	
F: university, M: no/missing educ.	0.009	−0.012	0.024	
	(0.012)	(0.015)	(0.010)**	
F: university, M: vocational educ.	0.037	−0.022	0	
	(0.016)**	(0.022)	(0.016)	
Both parents with university educ.	0.018	−0.037	−0.027	
	(0.014)	(0.020)*	(0.014)*	
Correction term λ		0.052	0.291	
		(0.106)	(0.120)**	
Log wage differential				0.074
				(0.023)***
Average partial effects for women				
Progressivism indicator	−0.000			0.000
	(0.009)			(0.009)
Log relative distance	−0.015			−0.022
	(0.009)			(0.009)**
Majority French	−0.035			−0.025
	(0.012)***			(0.013)**
Majority Italian	0.014			0.013
	(0.023)			(0.024)
Log age	−0.028	−0.010	0.019	

(continued)

Table 4. Continued

	Reduced Form STEM Choice (1)	Log Wage STEM (2)	Log Wage Non-STEM (3)	Structural STEM Choice (4)
	(0.008)***	(0.030)	(0.010)*	
Postgraduate education	−0.009	−0.124	−0.030	
	(0.008)	(0.025)***	(0.009)***	
F: no/missing, M: vocational educ.	0.007	−0.037	0.002	
	(0.009)	(0.032)	(0.010)	
F: no/missing, M: university educ.	−0.008	−0.010	0.012	
	(0.007)	(0.010)	(0.006)**	
F: vocational, M: no/missing educ.	−0.000	−0.026	0.008	
	(0.012)	(0.033)	(0.015)	
Both parents with vocational educ.	0.014	−0.011	0.003	
	(0.017)	(0.050)	(0.021)	
F: vocational, M: university educ.	−0.015	0.027	−0.005	
	(0.009)	(0.016)*	(0.012)	
F: university, M: no/missing educ.	0.018	−0.018	−0.024	
	(0.010)*	(0.028)	(0.014)*	
F: university, M: vocational educ.	0.001	−0.007	−0.002	
	(0.015)	(0.039)	(0.017)	
Both parents with university educ.	0.002	−0.063	−0.022	
	(0.013)	(0.036)*	(0.015)	
Correction term λ		0.171	0.289	
		(0.163)	(0.184)	
Log wage differential				0.009
				(0.011)

Note: See Table 3.
Source: Authors' calculations using Federal Statistical Office of Switzerland, Année Politique Suisse.

corresponding gender interactions are not significantly different from zero. Most interestingly, we see that the effects of progressivism largely differ across gender both in magnitude and statistical significance, by contrast. For men (first panel of Table 4), an increase of the progressivism indicator by one standard deviation lowers the probability to study a STEM major by 3.9 percentage points in the structural estimation (column [4]). The average partial effect is significantly different from zero at the 1% level and similar to the reduced-form estimation (column [1]). For women (second panel), by contrast, not only is the average partial effect of the progressivism indicator statistically not different from zero but also literally zero in magnitude in both the reduced-form and the structural estimation, according to column (1) and (4), respectively.

Average partial effects of pecuniary incentives to study a STEM field are different for men and women, too. For men, the increase in the fraction of STEM major graduates from an increase in the log wage differential by one standard deviation is 7.4 percentage points and highly significant (column [4]). By contrast, the average partial effect of the log wage differential (STEM versus non-STEM) for women is very small and insignificant. It is thus safe to conclude that pecuniary returns to graduating in a STEM field matter considerably less for women than for men. As for the progressivism indicator, the gender interaction effect is highly significant.

With respect to earnings regressions, we see that postgraduate education reduces earnings for both genders, according to columns (2) and (3). Moreover, interestingly, the positive estimates for the coefficient on the selection correction term in the non-STEM equation ($\hat{\gamma}_0 > 0$) suggest that both men and women are positively selected into non-STEM fields. Albeit the coefficient is significantly different from zero for men only, the gender difference is insignificant. Both genders do not seem being particularly selected into STEM fields.

5.4 Sensitivity analyses

We summarize the results of sensitivity analyses we implemented to examine support for our exclusion restrictions and robustness of size and significance of the effects of interest. All detailed results are relegated to the Online Appendix.

Our first set of sensitivity analyses addresses the concern that the effect of sociocultural characteristics in a municipality on individual major choice could be contaminated by unmeasured heterogeneity in local economic conditions that may shape tastes as well as earnings associated with different study fields. Controlling for the broader (i.e. *NUTS*-2) region a student resided in before entering university may not suffice if economic integration within regions is low. Moreover, it could be the case that municipalities with more progressive attitudes also have higher female employment rates. We thus estimate a richer model that includes at all stages additional variables capturing the economic environment in the home municipality at the time of major choice. We start by including the total employment rate, the female employment rate, and the municipality size. Coefficients of these additional variables are not significantly different from zero in a joint test. Average partial effects on the progressivism indicator, relative distance to the next technical university, and the log wage differential for university major choice at stage 3 remain at significance levels of the benchmark model. An increase by one standard deviation in the progressivism indicator and in relative distance reduces the probability to study STEM by 2.6 and 2.3 percentage points, respectively, comparable to the benchmark model. A similar picture arises when also adding the industry structure (employment shares in agriculture, manufacturing, construction, and business services) or the occupational structure among the high-skilled (employment shares in management occupations, technical occupations, and health, education, research, culture occupations). Results are remarkably robust and the additional economic indicators do not play any role, reflecting high economic integration of *NUTS*-2 regions and Switzerland as a whole.

Second, motivated by Card and Payne (2017), we extend the benchmark model to allow for high school choices of students, thereby controlling for major-specific ability. We include two dummy variables at all stages of the estimations that capture specializations in general high school: in math and sciences and in Latin language. Both specializations are typically also associated with high analytical ability. In secondary school, 57.2% of STEM graduates specialized in math and science, compared to only 17.5% of the non-STEM graduates. Only 23.3% of STEM graduates chose a specialization containing Latin language, compared to 38.8% of non-STEM graduates. Specializing in math and science raises the probability to choose a STEM field by 11.9 percentage points, whereas specializing in Latin language raises it by 2.6 percentage points. Importantly, according to the structural equation (stage 3), effect sizes and significance levels of the progressivism indicator, relative distance to the next technical university, and the earnings differential are similar to the benchmark model.

Third, we relax the restriction that the sociocultural characteristics do not affect earnings and allow them to enter the estimated equations in all stages. The progressivism indicator enters insignificantly in the earnings regressions. The point estimates in the structural equation are very similar but less precise compared with the specification that excludes the sociocultural characteristics at stage 2. Overall, this evidence lends support to our assumption that progressivism affects net subjective costs rather than pecuniary gains.

Fourth, we allow the relative distance to the next technical university to enter stage 2. We find that the coefficients on relative distance to the next technical university in the two earnings equations are not significantly different from zero in a joint test. Moreover, the earnings differential between STEM and non-STEM ('return to STEM') is not significantly related to relative distance, suggesting that potentially differential labour demand for graduates by municipality is not important for the return to STEM.[20]

6. Conclusion

We have examined the role of the sociocultural background of students for choosing a STEM field in university. The motivation to focus on the formation of STEM skills is rooted in their salient role for innovation-led economic growth. We have exploited the large regional variation of sociocultural attitudes combined with a high degree of economic integration in Switzerland. We employ rich survey data on university graduates and complement them with municipality level information from the census as well as nationwide referenda and parliamentary election results. In particular, we characterize a student's home environment with respect to progressive attitudes. The unique opportunity for our research mainly comes from two institutional features in Switzerland: (i) the frequently held national referenda in the Swiss direct democratic system; and (ii) the fact that at the time of our study all inhabitants with a general upper secondary education degree were free which field and at which university to study at very moderate tuition fees. We based the empirical identification on a generalized Roy model (Roy, 1951; Heckman and Vytlacil, 2007) which accounts for differences monetary and subjective costs and earnings across majors as well as for selection bias.

Our structural approach allowed us to directly compare the effect of the sociocultural background on major choice with the effects of pecuniary returns (the STEM wage differential) and costs (relative distance to the next technical university). Our findings suggest that sociocultural background is an important driver of major choice of men. In particular, male students from more progressive municipalities are less likely to study a STEM field. The effect of the sociocultural background of males is about half of the effect of the earnings return to STEM and twice as large as the effect of relative cost of studying a STEM field. For females, a progressive background plays no role for the decision to study STEM. Consistent with previous studies, we also find that female students are considerably less motivated by earnings than men.

20 To interpret the results of our third or fourth robustness check as a test of overidentification restrictions it would be necessary to maintain the hypothesis that the exclusion restrictions not under test are valid (i.e. log relative distance in the third robustness check and sociocultural characteristics in the fourth). We leave it to the reader to choose the maintained exclusion restriction.

From a policy perspective, at least for males, our results suggest important challenges for promoting the formation in STEM fields. Motivating students for those fields may require addressing culturally rooted biases against STEM education in progressive environments.

Future research may attempt to differentiate among the non-STEM fields. As this would probably require modelling major choice among more than two alternatives, identification will be an important challenge beyond the scope of the current article. The differential impact of the sociocultural environment on males and females certainly deserves further attention in future research as well.

Supplementary material

Supplementary material is available on the OUP website. It comprises the replication files (Stata do-files and regional data) and the Online Appendix. The Online Appendix contains the full structural model, details on the data sources, and further empirical evidence. The 'Swiss Graduate Survey' used in this article is confidential for data privacy reasons. It is available from the Swiss Federal Statistical Office.

Acknowledgements

We are grateful to the Associate Editor Ken Mayhew, two anonymous reviewers, Thomas Bauer, Bernd Fitzenberger, and seminar participants at the University of Fribourg, the University of St. Gallen, the Annual Congress of the International Institute of Public Finance (IIPF), the European Economic Association (EEA), the German Economic Association (Verein für Socialpolitik), the CESifo Area Conference in Economics of Education, the 4th SOLE/EALE World Conference, the annual conference of the population economics group of the German Economic Association, and the Asian Meeting of the Econometric Society for valuable comments and suggestions.

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