LELAM-TVET4INCOME

The effects of Professional Technical High School Education when applying to study for STEM undergraduate degrees at Chilean universities. A causal analysis based on observational data

Authors:

Miski Peralta,

Máximo Quiero,

Andrea Canales,

Luis Maldonado

Working Papers, No. 19, February 2020

Contact
Institute of Sociology
Pontifical Catholic University of Chile (ISUC)
Avenida Vicuña Mackenna 4860
Casilla 306, Correo 22
Macul, Santiago

Financed by:

Swiss Programme for Research on Global Issues for Development

FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

The effects of Professional Technical High School Education when applying to study for STEM undergraduate degrees at Chilean universities. A causal analysis based on observational data

Miski Peralta, Pontifical Catholic University of Chile, Chile[1]
Máximo Quiero, Pontifical Catholic University of Chile, Chile[2]
Andrea Canales, Pontifical Catholic University of Chile, Chile[3]
Luis Maldonado, Pontifical Catholic University of Chile, Chile[4]

Abstract

There is a persistent gender gap in undergraduate university degree programme admissions in the STEM area in Chile, even though today women represent more than half of higher education enrollments and obtain better academic results than their male peers at all educational levels. This research investigates the effects of receiving Technical-Professional Secondary Education (EMTP), compared to graduates of the General Secondary Education (EMCH), regarding the preference to study a subject in the STEM area at university level and addressing gender differences. The Full Matching method was used in order to make the groups comparable, through sociodemographic and educational characteristics. The results show the absence of significant differences in the university application preferences between EMTP and EMCH graduates. However, there are significant differences when considering the gender variable. Women who opt for EMTP apply in a smaller proportion to STEM courses, compared to women who choose EMCH, and in contrast, men who opt for EMTP apply in a greater proportion to STEM courses than men who choose EMCH. These findings are novel within the national literature on gender gaps and education, accounting for a double bias in STEM programmes, first by gender, and second, by the educational modality of the applicants.

Keywords: Gender gaps, Technical-Professional Secondary Education, University STEM Programmes, Causal Inference, applications to University Higher Education.

[1] mcperalta@uc.cl
[2] mfquiero@uc.cl
[3] acanales@uc.cl
[4] lmaldona@uc.cl

1. *Introduction*

The low participation of women in areas related to science, technology and mathematics (STEM) is widely documented by international literature (Niederle & Vesterlund, 2009; Akinsowon and Osisanwo, 2014; Australian Council of Learned Academies, 2012 , Bertrand, 2011; Bordon, Canals and Mizala, 2018, Charles and Bradley, 2009; Croson and Gneezy, 2009; Diaz Lucas, 2016, etc.). In OECD countries, only 14% of women who commenced studying at university for the first time opted for STEM degrees, versus 39% of men (OECD, 2015). In Chile from 2005 to 2016, the proportion of enrollments in STEM programmes was 40% for male students and only 20% for female students (Paredes and Duarte, 2017).

Regarding Higher Education in general, Bordón, Canals and Mizala (2017) state that women are more likely to apply to study on university degree programmes in the areas of Education (4%), Social Sciences and Humanities (4%) and Other Health programmes (13%), and are less likely to apply to study Engineering (-14.3%) and Technology (-6%) compared to men. Likewise, women access degrees with lower probability of employability and future income, and are more likely to apply to institutions where it is more feasible to be selected. In this sense, women are more adverse to taking actions that they consider to be risky (Bordón, Canals and Mizala, 2017).

With regards to wage gaps in Chile in particular, during 2015 women in Chile with higher education qualifications earned 65% of what men with the same educational level obtained (OECD, 2018). Despite having similar educational achievement rates, in Chile women are less likely to find employment. On average, 79% of women between 25 and 64 years of age who have graduated from higher education have paid work, compared to 91% of male graduates in the same age range (OECD, 2018).

Reducing gaps between men and women in access to university programmes in the STEM area and completion of them, as well as reducing wage inequality could lead to a series of positive consequences. At the micro level, STEM degrees have higher employability probabilities and higher incomes, making it an effective mechanism to reduce gaps at the level of job opportunities (OECD, 2015) and of insertion into the public space in general.

At the macro level, greater participation of women in STEM would have a significant effect on the growth of countries (Thévenon and Luci, 2012), as well as a greater demand for advanced human capital (Arcidiacono, 2004). Another positive attribute would be greater participation of women at the political level, improving the quality of democracies. Linn (2010) reports an significant association between the results of women in world standardized tests (TIMSS in particular) and parliamentary participation. In view of these considerations investigating the reasons that account for gender gaps in STEM could facilitate understanding them and thus, provide clues about what the factors are that mediate in the Chilean case in particular. In the following part, the factors identified by the literature that are at the base of this difference will be approached succinctly.

2. *Factors that affect STEM gender gaps*

Inquiring into the causes of low participation of women in STEM has been a long-standing challenge in academic research around the world (Charles and Bradley, 2002, 2009; Xie and Shauman, 2003; England and others, 2007). Initially, the literature emphasized a strong differentiation in the performance of male and female students. Currently, this cause seems to have been ruled out, since women have the same or higher academic performances as men at all educational levels, except for the standardized tests associated with STEM programmes, namely mathematics and science (OECD, 2015). Researchers have investigated the reasons for differentiation in standardized tests, which could be influenced by other aspects associated with "male values", such as the ability to tolerate pressure and competition (Correll, 2001; Bertrand 2011; Croson and Gneezy, 2009; Niederle and Vesterlund, 2011).

Furthermore, regarding the identification of psychosocial factors that explain gender gaps, there is a body of research that investigates the differences of self-perception and self-efficacy that women have regarding their performance in mathematics (Xie and Shauman, 2003; Mann and DiPrete , 2012; Charles and Bradley, 2002, 2009). The impact of these types of considerations can be observed at different stages of the life cycle. At the school stage, the literature identifies that girls underestimate their abilities and skills in mathematics, which impacts their results and their preferences for certain training routes over others (Eccles et al., 1998; Valian, 2007, Marsh and Yeung, 1997).

Indeed, women tend to make educational and career choices that allow them to reconcile their future potential parenting responsibilities with the demands of the world of work, preferring jobs with less responsibility, greater flexibility (England, Bearak, Budig, Hodges, 2016), and which are culturally desirable for them (Charles and Bradley, 2002, 2009). Following this logic, there are female jobs (associated with services and care) and male jobs (associated with STEM area programmes) (Mann and DiPrete, 2013). Within the literature, contextual factors have also been identified as keys in the preferences of men and women, such as the effect of peers, school and family, which directly influence the unversity studycareer choices of young people (Reimer & Pollack, 2009). Considering the aforementioned, this research focuses on the following question: Does graduating from Technical-Professional Secondary Education (EMTP) effect the preferences declared at the time of applying to study in university degree programmes in the STEM area? As a second question that addresses gender gaps: Are there gender differences within both teaching modalities (EMTP & EMCH) in the preferences declared at the time of applying to undergraduate university STEM programmes?

In the following part, a brief description will be made about Technical Education in Chile and its relationship with the gaps in the applications for places in STEM programmes at university level.

3. *Technical- Professional secondary Education in Chile.*

Technical education in Chile begins at secondary level, specifically in the high cycle of upper secondary education (3rd and 4th grade). The low and high cycles each have a duration of two years. The first two years feature general education with a transversal curriculum in general studies (Kis and Field, 2009). The last two years present the first possibility for students to choose between an academic and technical route. Students who wish to attend university generally follow the academic path (general education studies), while students who are interested in vocational education and training follow the path of professional technical education. All students who finish secondary education receive a certificate (High School Diploma), however, to complete technical-professional training it is necessary to carry out professional practice of 250 hours in a company. Currently, EMTP brings together a large number of students in the country: 35.8% of the enrollments in upper secondary education (3rd and 4th grade) (Ministry of Education, 2019). A characteristic of the Chilean educational system is its widespread private tuition subsidized by the State. In EMTP, 46.6% of students attend public establishments, while 53.3% attend subsidized private establishments (Ministry of Education, 2019). Students who select the technical track can choose between five branches (Commercial, Industrial, Technical, Agricultural and Maritime), which in turn are broken down into 15 economic sectors and 35 specialties (Arroyo and Pacheco, 2018).

On the other hand, in postsecondary education there are three main types of institution: universities, professional institutes and technical training centers (KOF, 2015, Sanhueza, 2015). This research focuses only on universities, analyzing the preferences for undergraduate degree programmes corresponding to level 6 of the UNESCO international standardized teaching classifier (UNESCO, 2010). Universities in the centralized admission system require students to sit a University Selection Test (hereinafter referred to as the PSU). On the contrary, most institutions on the track of professional technical education do not have admission requirements based on the national admission test, but set their own admission requirements. In Chile, the system allows for the transition between different educational levels, however, it does not provide specific transit routes for technical education students, from secondary to tertiary education. All high school graduates of both educational modalities (EMTP and EMCH) must take the PSU test in order to apply to university programmes.

4. Gender gaps in Professional Technical Secondary Education. National evidence

In Chile, high segregation in university programmes can also be observed in Professional-Technical Secondary education. The percentage of women who study the technical alternative versus academic programmes is 48.1% (76,196 women, 82,341 men) in 2016 (Arroyo and Pacheco, 2018). Of these, 80% chose a specialty from the Administration and Commerce branch (20,708) or the Technical branch (30,349), while only 15% opted for the Industrial branch. The economic sectors with the greatest female presence is Administration and Commerce, Social Programmes and Projects and Food (Arroyo and Pacheco, 2018).

Within the Social Programmes and Projects, the specialty "Preschool Teaching Assistants" has the highest concentration of women, accounting for 13% of the total enrollments of female EMTP students in Chile.

In the case of men, Industrial is the branch where there is the highest concentration of enrollments (50,765 students). Specifically in the metalworking economic sectors (21,379 students) and electricity (16,259 students) economic sectors.

Another important differentiation between men and women is the number of graduates who continue onto higher education: one in three women graduates from the Industrial EMTP branch continue their formative path at University, in contrast to 87% of men (Larrañaga, Cabezas and Dussaillant, 2014). On the other hand, women who studied at Professional-Technical Secondary Schools received, comparatively lower salaries than men, particularly those without university degrees. For the group of women who chose specialties of greater prestige and remuneration, the income penalty is even greater than for EMTP figures in general, resulting in a widening of the gap between them and their male peers. This becomes a disincentive for women regarding opting for programmes where the presence of men is dominant (Larrañaga, Cabezas and Dussaillant, 2014).

The general objective of this research is to identify if there are gender differences within both secondary teaching modalities in the preferences declared at the time of applying to study at university. The specific objectives are, first, to identify if - controlling for socioeconomic variables - there are differences in the application to degree programmes in the STEM area between EMTP and EMCH graduates. Second, to identify if - controlling for socioeconomic variables - there are differences in the application to study STEM degrees between men and women of EMTP and EMCH. Third, to identify if - controlling for socioeconomic variables - there are differences in the applications to degrees in the STEM area between women who graduated from professional technical secondary education and general secondary education. The specific objectives defined are complementary to the findings previously reported in the literature and represent an advance regarding investigating gender differences between teaching modalities in the preferences for University applications. This issue is particularly relevant considering the low application rates for graduates from EMTP to higher education (DEMRE, 2018) and the lack of data regarding the group that effectively manages to apply and be accepted.

In the following part, a review of the literature is carried out where the hypotheses of the present investigation are framed, specifically in relation to the variables that affect the preferences that students make in educational transitions.

5. Decisions and preferences in educational transitions

The question about preferences when choosing an educational route over another, and specifically an educational field, can be answered from different conceptual perspectives.

Mayer and Müller (1986) cited in Wolf et. al. (2011) state that decisions are made, taking into consideration the interaction of institutional regulations, social environments and individual capacities, competencies and resources. In this vein, Wolf et al. (2011) realize that educational transitions are the product of integrated social interactions that include results, choices, preferences, values and the experiences of others. The rational choice would complement this perspective, stating that decisions depend both on academic performance, as well as on the economic resources of families and the estimated probabilities of success that is taken into account when choosing one educational route over another.

For this theory, maintenance of the basic situation and risk aversion are two factors that, together, explain the differences in decision-making about educational alternatives. Becker and Hecken (2009) complement this perspective by stating that there are disparities in cost-benefit decisions between social classes, namely, the upper classes are more likely to worry about maintaining status than graduates from the working class. Thus, upper class graduates are more likely to estimate that their possible success at university is high, while working-class youth tend to estimate that the costs are higher than the potential benefits which might be obtained.

The common explanation for this finding is that the direct and indirect costs and benefits of a given educational transition, in terms of the probability of upward and downward mobility, are perceived differently by the distinct social classes (Breen and Goldthorpe, 1997; Breen and Yaish, 2006 cited in Bernardi and Triventi, 2018).

Another factor identified as key by the literature is the moment at which preferences occur, with adolescence usually being the life stage when decisions about career plans are made (Diekman et al., 2010; Eccles, 2009). Specifically for STEM programmes, the evidence suggests that the first interaction with science and mathematics occurs in primary and secondary education, however, the transition from high school to higher education has been identified as the point at which most students leave the trajectory of science and technology (Díaz Lucas, 2016).

The selection process seems to be highly determinant since students are more likely to apply to a programme to which the probability of being admitted is greater. Therefore, if women tend to have lower scores in the Mathematical Part of the PSU test than men, their likelihood of applying to study in areas where this test has an important impact on selection (such as science and engineering) will be lower. Following the theory of rational choice, EMTP graduates, apply less to university programmes in the STEM area, considering that most of them come from lower socioeconomic sectors than those graduates of general education (Arroyo and Pacheco, 2018).

Therefore, the first hypothesis that is proposed is the following: *Graduates of technical education (EMTP) apply more to STEM degree programmes than graduates of general education (EMCH), controlling for sociodemographic variables.*

Beyond the factors identified above, there is also literature that considers tracking as a central element of the differentiation between men and women, as well as in the choices they make with regards to university education (Eccles et al. 2004; Maltese and Tai, 2011; 2013; Legewie and DiPrete, 2014). "Tracking" is defined as the distribution of students in different classrooms according to one or more of the following attributes: 1. Previous achievements, 2. Expected future achievements and 3. Personal interests (Belfi et al. , 2012). In Chile, one can speak of two “routes” when referring to the differentiation between EMCH and EMTP, since the choice for one of the formative routes implies different educational grades.

The evidence shows the centrality of women's occupational aspirations in transitions from secondary to post-secondary education (Van de Werfhorst et al., 2003; Xie and Shauman, 2003). The low level of female preference for the route that culminates in STEM area degrees could be because women perceive them as inhospitable for the desired balance between work and family or as more hostile or colder environments (Mann and DiPrete, 2013). The evidence suggests that female university students are more likely than men to value the humanistic and vocational aspects of education (Mann and DiPrete, 2013). Men prefer jobs with high salaries, status and prestige; while, for women, the social and altruistic opportunities offered by work are more important (Marini et al., 1996; Jonsson, 1999).

Two hypotheses emerge from the factors associated with tracking, STEM area and gender. The first, which corresponds to the second hypothesis of the study, hypothesizes that male EMTP graduates apply in greater proportions to study degrees in the STEM area, compared to men who graduated from EMCH, controlling for sociodemographic variables. This hypothesis is based on the strong segregation that exists in the choice of specialties in secondary education between men and women and in the greater economic incentives which exist for men at the expense of women who graduate from EMTP. Assuming that a large part of men opt to study programmes in the industrial field and also considering cultural aspects that mediate the decision, it could be expected that male graduates from EMTP who achieve the minimum application score will choose the STEM area to a greater extent than male EMCH graduates.

The second hypothesis is that female graduates from EMTP apply to a lesser extent to degrees in the STEM area, compared to women who graduated from EMCH, controlling for sociodemographic variables. This hypothesis is in accordance with the evidence collected as it would be expected that women who graduate from EMTP having studied mainly “feminized” specialties, would also tend in higher education not to choose programmes in the STEM area, in comparison with their peers who graduated from EMCH.

It is important to realize the need to control for variables of origin and the previous academic performance of the students, considering the relevance they have in their preferences, otherwise, it would not be possible to make a comparison of two groups with different numerical compositions and sociodemographic characteristics. The social class of origin, the educational level of the mother, the time when the decision to choose one track or another is made, as well as the qualifications that the students already have are key factors to identify the preferences of the students.

5. *Methodology*

a. Database and study sample

For the investigation, a long data type database was built from the applications of all the students from the 2015 cohort that applied to the admission process using the databases of the DEMRE 2016, as well as the enrollment database for the year 2014 of the Ministry of Education.

The original database has 566,900 observations. For the study, only students with an average of 450 or higher points in the PSU Mathematics and Language and Communication tests were considered, a mandatory requirement that makes it possible to apply in the SUA. This was in order to have statisically valid applications.

Likewise, for reasons of analysis, computational processing and information management, a series of methodological decisions were made that allowed for the construction of a stratified random sample according to secondary educational modality. First, all students who applied to university during the 2016 admission process but who did not belong to the 2015 graduation cohort were removed from the sample framework. This is justified by the need to consider decision making at the end of 2nd grade for the 2015 cohort on the chosen educational modality, which implies having been enrolled at that level in 2013 (Diekman et al., 2010; Eccles, 2009) and for which there is information on their previous academic performance in language, math, science and history. Thus, an analysis was carried out to compare the difference between student decision making at the end of 2nd grade for educational modality (Diekman et al., 2010; Eccles, 2009) and they finally graduate in 4th grade (Díaz Lucas, 2016). 99.7% of the observations remained in the same educational modality.

Secondly, students who attended paid private establishments were removed from the database since these schools only teach EMCH. Then, considering that each applicant has a maximum of 10 possible applications and that the average of applications is 3.58, it was decided to consider the first 4 preferences of each student. Thus, a sample frame of 178,225 observations were obtained from which a stratified random sample was extracted according to educational modality (daytime and evening EMCH and EMTP) with 99% confidence and 3% error. The detail is presented in table 1.

Table 1

Sample frame and stratified random sample

Strata	Sampling Frame	Sample
EMCH daytime	152,043	1,827
EMCH evening	3,808	1,245
EMTP	22,374	1,708
Total	178,225	4,780

Source: own elaboration based on DEMRE 2016.

b. Variables

The two main variables are the treatment and the result (dependent variable), since it is sought to estimate if there are differences in the preferences for STEM programmes (result) of students who graduate from EMTP compared to those who do it from EMCH (treatment). Thus, Table 2 details how both variables were constructed from the DEMRE and MINEDUC databases.

Table 2

Treatment and outcome variables.

Variables	Description
Treatment	Variable built based on the educational modality from which the applicants graduate. The treaties (1) correspond to EMTP students who obtained at least 450 points in the PSU and who applied to universities that belong to the Single Admission System (SUA). On the other hand, the controls (0) are EMCH students (daytime and evening) who obtained at least 450 points in the PSU and who also applied to universities that belong to the Single Admission System (SUA).
Results	Variable construida en base a las preferencias de carreras develadas por cada uno de los postulantes, teniendo un máximo de 10 postulaciones por cada estudiante pero considerando las cuatro primeras para el estudio. Así, cada preferencia se categoriza en STEM (1) o No STEM (0) según corresponda. Variable built based on the preferences of undergraduate degrees for each of the applicants, with a maximum of 10 applications for each student but considering only the first four for the study. Thus, each preference is categorized into STEM (1) or Non-STEM (0) as appropriate.

Source: own elaboration based on DEMRE 2016.

For the generation of the causal model, a series of covariates are considered, which are detailed in Table 3 and which allow equivalent students to be compared when estimating the model.

Table 3

Covariables considered in the study

Variable	Description
Educational level of mother	Variable recodificada que señala nivel educacional de la madre según código ISCED 2011. Considera desde a categoría "sin estudios" hasta "educación universitaria" Recoded variable that indicates the mother's educational level according to ISCED code 2011. Considers a range of 5 categories from "without studies" to "university education"
Social class of father	Variable built based on the Goldthorpe class scheme and adapted by Torche (2006) for Chile, using the father's occupational level and the father's branch of activity. The Torche scheme is grouped into three social classes: service class, intermediate class and manual workers. The category "does not work" is also considered
Type of institutional financing	Variable that indicates the type of institutional financing from which students graduate. It was recoded into two categories: Municipal and Private State Subsidized, due to the absence of students from fully Privatized establishments in EMTP
Average scores for language	Average standardized grades of each student in language in 8th grade, 1st grade and 2nd grade
Average scores for maths	Average of standardized grades of each student in mathematics in 8th grade, 1st grade and 2nd grade
Average scores for Science	Average of standardized grades of each student in science in 8th grade, 1st grade and 2nd grade
Average scores for history	Standardized grade point average for each student in history in 8th grade, 1st grade and 2nd grade

Source: own elaboration based on DEMRE 2016.

c. Analysis method

According to Maldonado, Kronmüller and Gutiérrez (2016), firstly it is necessary to clearly and consistently define the causal model that underlies the hypotheses of the study. For the purposes of this study, it is necessary to analyze the effect of having completed EMTP and EMCH in the preferences for applying to the University.

Secondly, it is necessary to evaluate the assumptions that must be met in order to establish a causal effect. The three main assumptions are: Independence, exclusion restriction and Stable Unit Treatment Value Assumption (SUTVA). Regarding independence, it refers to the interchangeability of treated and controls. The potential results are expected to be identical prior to the effect of treatment on the subjects. This is ensured through the random assignment of individuals to both treated and controls. For this study, the aformentioned is operationalized in that the probability of applying to study an undergraduate degree in the STEM area is randomly distributed among those who graduated from EMTP and EMCH. In this particular analysis, in addition to being an observational study that cannot ensure ex-ante randomization, the evidence suggests (Sevilla, 2012) that those who opt for EMTP come from lower income quintiles and report indicators of educational achievement lower than those entering EMCH. The former fewer hours of general training, which accentuates academic differences and expectations for further studies. Therefore, this first assumption, then, is not met by directly comparing both population groups.

The second assumption of interest, exclusion restriction, refers to the fact that there is no other variable that we cannot control that affects the causal relationship between the treatment and outcome variable. This is achieved through the incorporation of covariates measured prior to treatment allocation and therefore to the outcome variable. The database that was utilized has an acceptable amount of covariates of socioeconomic origin and educational characterization to be incorporated into the analysis and that are prior to the assignment of cases to treated and controls (tracking at the end of second medium between EMCH and EMTP).

SUTVA refers to the exposure of a unit that we call “i” to the treatment we call “t”. The value of the result variable “Y” for that unit i will be the same without affecting the mechanism used to assign the treatment t to the unit i and what treatment the other units receive. In this case, it is interesting that the preferences for applying to study a STEM undergraduate degree are not affected by the interaction between those who are graduates from EMTP and EMCH.

The three aforementioned assumptions described, give an account of a possible problem in the balance between treated and controls, particularly regarding independence and the restriction of exclusion. As mentioned earlier, observational studies cannot ensure random assignment, and must deal with the assumption of interchangeability of treated and control groups, so that the characteristics of the subjects must be balanced.

To address this problem, the use of full matching was considered in this study. According to Stuart and Green (2008), the objective of full matching is to ensure that the distribution of the covariates observed in the treatment and control groups are similar, simulating what would have happened if the treatment had been randomly assigned. Thus, through the calculation of the propensity score that considers the covariates presented in Table 3, it is possible to have subjects comparable to each other that simulate the randomness in the allocation to treated and controls according to the observed covariates. All covariates considered correspond to characteristics of the subjects prior to the application of the treatment. The benefits of this method are defined by the same authors as, i) the reduction of bias in the estimation of the causal effects when there is no normal distribution; ii) a more intuitive explanation of the results and; iii) diagnostics easier to interpret.

The method works by grouping individuals into a series of paired sets (subclasses), with each combined set containing at least one treated individual (who received the treatment of interest) and at least one individual comparison (which did not receive it). Meanwhile, the Full Matching technique allows comparisons to be constructed to condition by covariates. Therefore, conditional independence or selection of observed variables is assumed, simulating what would happen if there were a randomized block experiment within each stratum constructed based on observed covariates (Rosenbaum, 2010). Based on the aforementioned, it indicated that both the principle of independence and the restriction of exclusion are complied with.

Regarding the third assumption in question (SUTVA), the present investigation assumes that based on the high segregation (Valenzuela, Bellei and De Los Ríos, 2010) of the Chilean education system, the interference between EMTP and EMCH students is low and non-systematic, particularly related to university application decisions, so this should not be a problem for the estimation of the effect of interest.

However, it is necessary to consider the appropriate covariates in the propensity score to comply with the assumptions and assign causality to the estimation of the effect at different levels. First, at the school level, dependence on the educational establishment is relevant since it affects the expectations of the applicants and is a good indicator of the socioeconomic level of the students. Second, at the family level, the father's social class and the mother's educational level are relevant to consider as indicators of the socio-economic and cultural level of the students and the expectations of the family and the students themselves about their futures. Finally, at the individual level, the scores in language, mathematics, science and history are an indicator of the academic performance of the students prior to the selection (tracking) of educational modality at the end of 2nd grade. It is then possible to compare the preferences before choosing a specific track, so that it is possible to control the effect of having chosen an EMCH or EMTP.

6. *Results*

a. Method to estimate the average treatment effect

To estimate the average treatment effect (ATE), the first step is the estimation of the propensity score through a logistic regression between the treatment variable and the covariates, and then reviewing the pre-matching balance. Second, different versions of full matching were tested in order to analyze which delivered a better balance. Thus, matching without restrictions and without caliper on the propensity score (matching 1) was performed first. Then, matching was also estimated without restrictions and without caliper on the propensity score but calculating the Mahalanobis distance with information directly from a regression between the treatment variable and the propensity score (matching 2). Finally, matching on the propensity score was made without restrictions with a caliper of 0.25 (matching 3). The statistical test (Hansen and Bowers) was used and it was found that the three matching models have similar results (e.g. value equal to or greater than 0.68), with the third (matching 3) having the best results (Table 4) . Therefore, it is the one which was selected for the estimation of the ATE and for the post-matching balance.

Table 4

Statistical test to evaluate matching

	Chi squared	df	*p. value*
Original	703.76	12	0.000
Matching 1	9.20	12	0.686
Matching 2	9.06	12	0.698
Matching 3	8.96	12	0.707

Source: own elaboration based on DEMRE 2016.

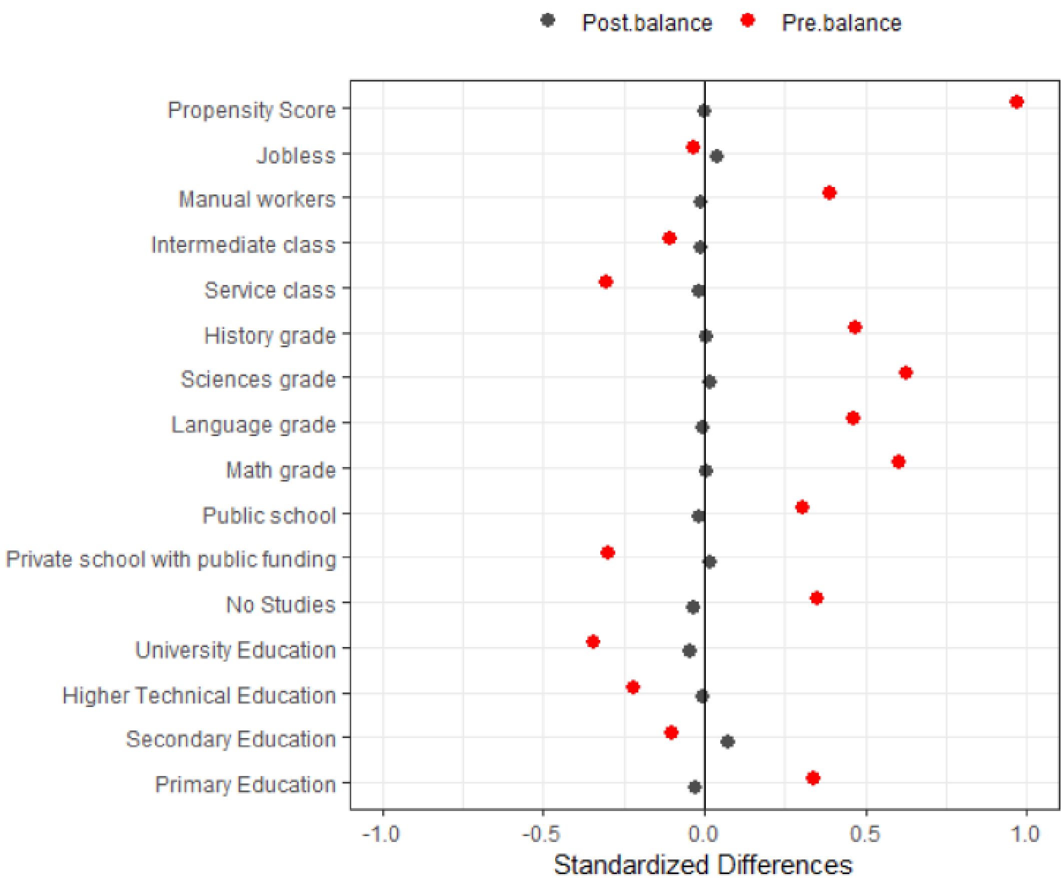
Figure 1 shows the results of the balance for the variables considered in the study, specifically the standardized difference both before and after matching. The means of the treated and control groups for each variable and the associated categories, as well as the standardized differences are found in detail in Annexe 1 (Table A1).

It is observed that prior to matching, in general there is an imbalance in the covariates considered for the treated (EMTP) and controls (EMCH) that are expressed in the value of the propensity score for treated and controls represented in Figure 1, as well as in the standardized difference of 0.947.

When analyzing the standardized differences between the covariates, the greatest gaps are found in the previous performance of the students, where students who opt for and graduate from EMTP generally have better average performances in the four learning subsectors considered. However, the greatest standardized differences are observed in mathematics and science (values around 0.6), areas that are especially relevant for the choice of STEM degrees, followed by language and history with standardized differences around 0.5.

Figure 1

Box plot with propensity score values for treated (1) and controls (0)



Source: own elaboration based on DEMRE 2016.

Students who graduate from the EMCH mostly studied at subsidized private establishments (71%) and only 29% from municipal establishments. In the case of students who graduate from EMTP, the distribution is more equitable, but it is still greater in subsidized private establishments (55.5%), which translates into a standardized difference of -0.339. Regarding social class, EMCH students have a higher proportion of parents who are of the service class (19.1%) and intermediate class (26.7%) and a lower percentage of the manual workers class (24.0%) compared to the parents of EMTP students (6.2%, 24.7% and 39.3% respectively). In this variable the greatest standardized difference is found for the category "service class" with -0.359 followed by "manual workers" with 0.344. Finally, there is an imbalance in the mother's educational level in some categories, namely, EMCH students have a higher proportion of mothers with tertiary education (14.2%) in relation to EMTP students (3.2%) which translates into a standardized difference of -0.351 between both groups. The latter have a higher proportion of mothers without tertiary qualifications and who completed primary education (38.2% difference between both categories) in contrast to 19.3% of those who graduated from EMCH, which translates into a standardized difference of 0.257 and 0.346 respectively.

To have comparable groups we proceeded with full matching and a balance was obtained that is acceptable represented in Figure 1 by the black dots. It is observed that the standardized differences for all variables and categories are around 0 and comply with being less than 0.10 (see table A1) which meets standards for this type of analysis (Rosenbaum, 2010).

To perform the first calculation of the ATE and verify compliance with hypothesis 1, a linear regression with robust standard errors is used as a model and considering the results of the full matching performed as fixed effects. Thus, the following equation was defined:

$$Y_i = \beta \cdot X_i + \varepsilon_i$$

Where,
Y_i: Variable result corresponding to the individual's application i
β: coefficient equivalent to the ATE
X_i: Variable treatment indicates whether the individual and discharge from EMTP (1) or from EMCH (0)
ε_i: error term for the individual i

Table 5

Model 1 – ATE Estimation

	Model 1
Treatment (ATE)	0.034 (0.019)
R^2	0.33
R^2 adjusted	0.15
Number of observations	4768
RMSE	0.62

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.

Source: own elaboration based on DEMRE 2016.

It is observed that although the effect of studying in EMTP implies that on average the students apply by 3.4% more to STEM degrees compared to those who graduate from the EMCH this difference is not statistically significant, which does not allow for the verification of the first hypothesis. However, considering the two remaining hypotheses of this research, a key element to analyze is the gender gaps that occur and if there is indeed a causal effect associated with gender. Given the relevance, gender heterogeneity is addressed separately in the following section to respond to these hypotheses and analyze their implications.

b. Heterogeneity by gender

To study heterogeneity a linear regression with robust standard errors was used and incorporated the interaction between the treatment variable and the sex of the applicants (Model 2). This has a substantive justification, given that - according to the evidence - men and women may have different behaviors which need to be analyzed separately. The results obtained are presented in Table 6 and the fundamental element is that all the coefficients considered are statistically significant with 99.9% confidence.

Table 6

Models 2, 3 and 4 – ATE Estimation

	Model 2	Model 3
Treatment (ATE)	0.092 *** (0.027)	0.039 *** (0.004)
Sex: Female (Ref.: Men)	-0.198 *** (0.018)	-0.247 *** (0.002)
Treatment x sex	-0.134 *** (0.037)	-0.071 *** (0.006)
Fixed effects	Yes (matching)	No
Covariables	No	Yes
R^2	0.38	0.15
R^2 adjusted	0.21	0.15
Number of observations	4768	178225
RMSE	0.59	0.43

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.

Source: own elaboration based on DEMRE 2016.

The first finding is that male students who graduate from EMTP apply 9.2% more to study STEM degrees than students who graduate from EMCH. This is consistent with the second research hypothesis, since the men who opted for EMTP at the end of the second grade apply to study STEM degrees in greater proportion than their peers who choose EMCH.

In contrast, female students who graduate from EMTP apply 4.2% less to STEM degrees than those who graduate from EMCH which is consistent with the third hypothesis of the study. Likewise, model 2 also shows that women on average apply less to STEM degrees than men. In fact, female students who graduate from EMCH apply 19.8% less than their male peers, la difference is even greater in the case of students who graduate from EMTP who apply 33.2% less to STEM degrees than their male peers. In fact, these findings show that the tracking between both educational modalities generates an increase in the gender gap between male and female students.

On the other hand, as a way to analyze the robustness of the results obtained, a fourth model is estimated through a linear regression with robust standard errors, without considering matching between both groups, but incorporating the covariates considered for the propensity score in the regression and using all the observations of the sampling frame. The results obtained are similar to those obtained in model 2, they are also statistically significant with 99.9% confidence. This is a good indicator that the results obtained by the estimated quasi-experimental models can be considered to be robust.

Therefore, based on the results of the different models, it is possible to conclude that the differences in preferences when applying to undergraduate degree programmes in the STEM area between men and women presented in previous studies, also have expression between the different modalities (EMTP or EMCH) attended by applicants during the second part of secondary education. Women who graduated from institutions with

technical-vocational training tend to apply less to STEM degrees than women who graduated from EMCH, while men who opted for EMTP apply more to STEM degrees than their peers in EMCH. This implies that gender gaps increase as tracking occurs at the end of the second half, which presents a relevant challenge for existing educational policies and future research possibilities that are presented in the next section.

7. Conclusions

The interest of the present investigation was in observing differences in the applications of men and women to STEM undergraduate degrees, mediated by the educational modalities in secondary education, EMTP or EMCH. Thus, the study reports findings that allow us to deepen our understanding of the factors that explain the low presence of women in higher level STEM study programmes. The use of a quasi-experimental methodology allowed for the comparison of two population groups that have a wide heterogeneity in their characteristics (EMTP and EMCH), homologating sociodemographic characteristics and previous academic performance, thus obtaining causal effects.

Technical education in Chile has a wide enrollment in the country, almost 40% at the secondary and tertiary levels (Mineduc, 2018). This accelerated growth is not consistent with an expansion of evidence regarding the impact within the training paths. The findings of the present investigation are then novel, not only for the technique used, but also for their results. To account for an increase in the gender gap resulting from graduating from professional technical education is an expression of a double bias in entering STEM programs. On the one hand, women apply to study STEM programmes at univerity, but particularly those who graduate from EMTP face a double disadvantage. The strong differentiation in the choice of specialties at the secondary level is in concordance with the findings presented by this study and in this sense, be a space for shortening gaps prior to the choice of higher-level programmes. This finding is in line with the evidence which defines adolescence as the time of the greatest distance between male and female educational preferences occurs.

Further research could investigate, first, differences by specialty or branches in EMTP. A greater disaggregation could demonstrate differences between industrial and technical programmes. In turn, and along the same lines, it is also necessary to identify what are the preferences of men and women in transit from secondary education to Higher Technical Education and not only to their University alternative. International evidence argues that within STEM programmes there are differences between Science and Engineering-oriented programmes (Mann and DiPrete, 2013). An investigation that disaggregates STEM areas could contribute in this line.

At the methodological level, it is possible to continue with lines of research that use quasi-experimental techniques through the use of secondary data of public access, with the aim of investigating new segmentations present in the Chilean educational system, such as administrative agency, regional or performance differentiations. Comparing two groups matching sociodemographic characteristics is beneficial both for academic discussion and for public policies in the area. At the same time, it is suggested to explore in context and psychosocial variables that influence students' career choices, such as expectations about the future, cultural and performance origins. The data provided by the SIMCE Test in the quality and context questionnaires would be essential to consider for these purposes.

Finally, it is important to highlight that, in Chile, public policies have been developed to reduce gender gaps, mainly in the workplace (childcare provisions, maternity leave, etc.). Choices and preferences for undergraduate university programmes have not been investigated as much as those at the school level, nor have significant incentives been generated that promote the entry and permanence of women to industrial specialties or related to STEM programmes. This change of approach is perhaps a pending, fundamental and complex task for Chile, due to the cultural mechanisms that mediate the reduction of gaps and their consequent effects on income. In sum, continuing with this research line could illuminate a space little explored by national academic literature, and in turn, contribute to evidence that contributes to public policy decisions around gender gaps in educational spaces.

Appendix A

Table A1

Balance of covariates before and after matching

	Pre-matching			**Post-matching**		
	Half treated	Half control	Standardized difference	Half treated	Half control	Standardized difference
Mother's education level						
Without studies	0.104	0.044	0.257	0.082	0.089	-0.027
Primary education	0.282	0.149	0.346	0.227	0.233	-0.018
Secondary Education	0.529	0.557	-0.057	0.573	0.546	0.054
Tertiary Technical Education	0.053	0.107	-0.188	0.072	0.070	0.010
University Education	0.032	0.142	-0.351	0.045	0.062	-0.053
Type of institutional financing						
Private-Subsidized	0.555	0.713	-0.339	0.613	0.605	0.017
Public Municipal	0.445	0.287	0.339	0.387	0.395	-0.017
Father's Social Class						
Service class	0.062	0.191	-0.359	0.089	0.103	-0.040
Intermediate class	0.247	0.267	-0.047	0.267	0.253	0.031
Manual class	0.393	0.240	0.344	0.347	0.345	0.030
No work	0.299	0.302	-0.007	0.297	0.298	-0.002
Previous academic performance						
Mathematics scores	0.603	0.038	0.611	0.469	0.478	-0.010
Language scores	0.448	0.056	0.447	0.352	0.372	-0.023
Science scores	0.538	-0.004	0.588	0.405	0.422	-0.018

History scores	0.458	0.007	0.511	0.355	0.361	-0.007
Propensity score	0.369	0.222	0.947	0.330	0.330	0.000

Source: own elaboration based on DEMRE 2016.

8. *References*

Arcidiacono, Peter, 2004. "Ability sorting and the returns to college major," Journal of Econometrics, Elsevier, vol. 121(1-2), pages 343-375.

Ainsworth y Roscigno (2005). Stratification, School-Work Linkages and Vocational Education. Social Forces, Volume 84, Issue 1, September 2005, pp. 257–284, https://doi.org/10.1353/sof.2005.0087

Akinsowon, O. A., & Osisanwo, F. Y. (2014). Enhancing Interest in Sciences, Technology and Mathematics (STEM) for the Nigerian Female Folk. International Journal of Information Science, 4(1), 8-12.

Arroyo, C. y Pacheco, F. (2018). Los Resultados de la Educación Técnica en Chile. Nota Técnica Comisión Nacional de Productividad.

Australian Council of Learned Academies (2012). Consultant Report Securing Australia’s Future STEM: Country Comparisons.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bertrand, M. (2011). New Perspectives on Gender.

Becker y Hecken, 2009). Higher Education or Vocational Training? An Empirical Test of the Rational Action Model of Educational Choices Suggested by Breen and Goldthorpe and Esser.

Belfi, B., Goos, M., Fraine, B. De, & Van Damme, J. (2012). The effect of class composition by gender and ability on secondary school students’ school well-being and academic self-concept: A literature review. *Educational Research Journal*, pp. 62–74.

Bernardi y Triventi (2018). Compensatory advantage in educational transitions: Trivial or substantial? A simulated scenario analysis.

Breen y Goldthorpe (1997). Explaining educational differentials: Towards a formal rational action theory.

Busemeyer y Jensen (2012). Inequality and the political economy of education: An analysis of individual preferences in OECD countries.

Bordón, Canals y Mizala (2018). Gender Differences in College Major Choices. The case of Chile.

Dupriez, V. (2010). Methods of Grouping Learners at School. Paris: UNESCO.

Charles, M. and Bradley, K. (2009). Indulging Our Gendered Selves? Sex Segregation by Field Of Study in 44 Countries.

Chmielewski, A. K., Dumont, H., & Trautwein, U. (2013). Tracking Effects Depend on Tracking Type: An International Comparison of Students’ Mathematics Self-Concept. *American Educational Research Journal*, pp. 925–957. https://doi.org/10.3102/0002831213489843

Correll (2001). Gender and the Career Choice Process: The Role of Biased Self-Assessments.
Croson y Gneezy (2009). Gender Differences in Preferences.
DEMRE (2018). Análisis de la participación de los estudiantes egresados de la Educación Media Técnico Profesional (EMTP) en el Proceso de Admisión del Consejo de Rectores y su desempeño según eje temático de la PSU.
Diekman et al., 2010; Eccles, 2009).
Díaz Lucas, S. (2016). Promoción Estudios STEM, Ciencia, Tecnología, Ingeniería y matemáticas. Barreras a la participación de la mujer en STEM.
DiPrete (2013). Rise of Women, The Growing Gender Gap in Education and What it Means for American Schools.
England, Bearak, Budig, Hodges (2016). Do highly paid, highly skilled women experience the largest motherhood penalty?
Eccles y Frome (1998). Parents' Influence on Children's Achievement-Related Perceptions.
Eccles (2004). The Relation of Early Adolescents' College Plans and Both Academic Ability and Task-Value Beliefs to Subsequent College Enrollment.
González, M. E. (2018). Análisis de la participación de los estudiantes egresados de la Educación Media Técnico Profesional (EMTP) en el Proceso de Admisión del Consejo de Rectores y su desempeño según eje temático de la PSU. Seminario de Estadística Educacional. Secretaria General. Consejo de Rectores de las Universidades Chilenas.
Green, K. M. & Stuart, E. A. (2014). Examining moderation analysis in propensity score methods: application to depression and substance use. Journal of consulting and clinical psychology, 82(5).
Hansen, B. B. (2004). Full matching in an observational study of coaching for the SAT. *Journal of the American Statistical Association*, pp. 609-618.
Ho, D. E., Imai, K. King & Stuart, E.A. (2007). Matching as nonparametric preprocessing. For reducing model dependence in parametric causal inference. *Political análisis*, 15. (3), 199-236.
Jonsson (1999). Explaining Sex Differences in Educational Choice An Empirical Assessment of a Rational Choice Model, *European Sociological Review*, Volume 15, Issue 4. https://doi.org/10.1093/oxfordjournals.esr.a018272
Kis, V. and Field, S. (2009). A Learning for Jobs Review of Chile. *OECD Reviews of Vocational Education and Training*. Paris: OECD Publishing.
Larrañaga, Cabezas & Dussaillant (2014). Trayectorias educacionales e inserción laboral en la enseñanza media técnico profesional. Estudios Públicos. 134. 7-58.
Legewie y Di Prete (2014). The High School Environment and the Gender Gap in Science and Engineering.
Linn (2010) Else-Quest NM1, Hyde JS2, Linn MC3. Cross-national patterns of gender differences in mathematics: a meta-analysis.
Maldonado, Kronmüller y Gutiérrez (2016). Estrategia para la inferencia causal y planificación de estudios observacionales en las Ciencias Sociales: el caso de Chaitén post erupción del 2008.

Mann, A. and DiPrete, T. (2013) Trends in gender segregation in the choice of science and engineering majors. Columbia University, Department of Sociology, MC9649, 606 W 122nd St., New York, NY 10027, United States.

Maltese y Tai (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students.

Marsh y Hau (2003). Big-Fish--Little-Pond effect on academic self-concept: A cross-cultural (26-country) test of the negative effects of academically selective schools.

Marsh y Yeung (1997). Causal effects of academic self-concept on academic achievement: Structural equation models of longitudinal data.

Ministerio de Educación (2019). Datos abiertos del Ministerio de Educación. Recuperado el 27 de septiembre de 2018: http://datosabiertos.mineduc.cl/

Ministerio de Educación (2018). Estadísticas de la Educación 2017. Centro de Estudios Mineduc.

Niederle y Vesterlund (2011). Gender and Competition.

OECD. 2015. The ABC of Gender Equality in Education: Aptitude, Behavior, Confidence.

Nagengast, B., & Marsh, H. W. (2012). Big fish in little ponds aspire more: mediation and cross-cultural generalizability of school-average ability effects on self-concept and career aspirations in science. *Journal of Educational Psychology*, 104(4), 1033-1053. https://doi.org/10.1037/a0027697

Nun, E. (2017) "Desigualdades de género en la Educación Media Técnico Profesional" Espacio Público.

OECD (2018). Estudios Económicos de la OCDE. Chile.

Paredes y Duarte (2017). Efecto de los colegios mixtos en la Elección de Carreras STEM.

Reimer, D., and R. Pollack. 2009. Educational expansion and its consequences for vertical and horizontal inequalities in access to higher education in west Germany. *European Sociological Review 26,* no. 4: 415–30.

Rosenbaum, Paul R. 2010. Design of Observational Studies. Berlin: Springer.

Sevilla, M. (2017): Desigualdades de género en la Educación Técnico Profesional. Tendencias, respuestas, otras interrogantes y agenda de investigación.

Shen y Tam (2008). The paradoxical relationship between student achievement and self-perception: A cross-national analysis based on three waves of TIMSS data.

Stuart, E. A, & Green. K. M. (2008). Using full matching to estimate causal effects in nonexperimental studies: examining the relationship between adolescent marijuana use and adult outcomes. Developmental psychology, 44(2), 395.

Sevilla, M. (2012). Educación Técnica Profesional en Chile, antecedentes y claves de diagnóstico. Santiago: Ministerio de Educación. Gobierno de Chile.

Travers, M.-C. (2018). Learners' attitudes to mixed-attainment grouping: examining the views of students of high, middle and low attainment. *Research Papers in Education*, 1–20. https://doi.org/10.1080/02671522.2018.1452962

Thévenon, O. & Luci, A. 2012. "Reconciling Work, Family and Child Outcomes: What Implications for Family Support Policies?" P*opulation Research and Policy Review*,

Springer; Southern Demographic Association (SDA), vol. 31(6), pages 855-882, December.
UNESCO (2010): Clasificación Internacional Normalizada de la Educación (CINE) 2011 – Versión Preliminar.
Valenzuela, J. , Bellei, C. y De Los Río, D. (2010). Segregación Escolar en Chile.
Valian (2007). Women at the Top in Science--And Elsewhere.
Van de Werfhorst, H.G., Sullivan, A. and Cheung, S.Y. (2003) Social Class, Ability and Choice of Subject in Secondary and Tertiary Education in Britain. British Educational Research Journal, 29, 41-62.
Wolf, Solga, Leuze, Dombrowski, Künster, Ebralidze, Fehring, Kühn (2011).
Xie, Yu, and Kimberlee A. Shauman. 2003. Women in Science: Career Processes and Outcomes. Boston, MA : Harvard University Press.