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Employment opportunities and university degree choice: an analysis on the underrepresentation of women in STEM

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Contents

1 Introduction

"The European Parliament considers that, in the light of the considerable gender pay gap in the EU, the fact that women are more likely to have low-wage, part-time and otherwise precarious jobs, the rising demand for STEM practitioners, and the importance of STEM-related careers for the future of the European economy, increasing the share of women in the STEM sector is critical to fulfilling women's rights and potential and to building a more sustainable and inclusive economy and society through scientific, digital and technological innovation" (European Parliament, 2021).

This is part of paragraph 1 of the European Parliament resolution on promoting gender equality in science, technology, engineering and mathematics (STEM) education and careers, which is just one of the several legal documents approved in the last years by organizations all over the world with the aim of promoting female participation in the STEM fields. The increasing awareness on gender stereotypes (also concerning occupations), combined with a growing recognition of the disadvantaged working conditions of women in certain sectors, brought the issue of the underrepresentation of women in science, technology, engineering and mathematics to the centre of attention in different contexts.

Events, conferences, awards and competitions are organized every year to raise awareness on the topic and economists, psychologists and sociologists attempt to understand the root causes of this phenomenon. Nevertheless, the legacy of the past regarding gender roles is still very present and women are still a minority in both education and occupation in STEM fields, also in developed countries.

Stereotypes operate in two directions in this context. On the one hand, they prevent girls from getting interested in science and discourage young women who opted for a STEM career to pursue it, decreasing their sense of belonging in these fields. On the other hand, they lead schools, universities, firms and organizations to implicitly favour male students and workers, creating a male-dominated environment in which women do not feel welcome. The interaction between these two aspects is one of the main causes of the permanence of this problem and it is the starting point of any intervention.

In light of these considerations, the objective of this thesis is to analyse the relationship between the employment opportunities and girls' choice of pursuing a STEM degree at university. The empirical Section of this dissertation, in particular, examines this topic in the Italian context before the Covid pandemic.

The thesis is structured into three main Chapters.

In the first Chapter, numerous possible definitions of STEM are presented, together with the problems that arise from the presence of multiple definitions of this sector. The current situations of women in both STEM education and labour market are then described, starting from a wide global perspective and progressively narrowing the perspective to the Italian context. A number of policies aimed at including more women in STEM are finally reported, highlighting also their unintended effects and some possible solutions.

The second Chapter is a review of the current literature on this topic. This Section is composed of two parts: the first concerns the labour market situation and its link with the degree choice, and the second regards other factors that influence the major choice. More in detail, the first part examines articles about the gender pay gap, the glass ceiling and the glass cliff effects, and the Matilda effect and how these issues impact the girls' decision to pursue a STEM career. The second part looks more closely at the peer effects in high school years and the role of teachers in influencing this crucial decision.

The last main Chapter is dedicated to the empirical analysis based on the dataset that emerged from the survey "Inserimento professionale dei laureati" ("Labour market conditions of University graduates") 2015 edition, carried out by the Istituto Nazionale di Statistica (ISTAT). The first part of the chapter describes the data, with particular focus on the structure of the survey, the variables of interest and the methodology of the analysis. Next, there descriptive statistics are used to illustrate the main characteristics of the sample for what concerns the aspects that are relevant for the analysis. The results of the econometric analysis are then reported, focusing firstly on the gender differential in working conditions in STEM versus non-STEM fields and secondly on the willingness to re-enrol in the same degree program of STEM and non-STEM graduates. This Section closes with the policy implications of the study.

The main results of both the review of the literature and the analysis and their implications are summarized in the final chapter.

2 Definitions, stylized facts and policies

2.1 Definitions

Before starting to analyse the relationship between employment conditions and the choice of studying a STEM discipline for women, it is crucial to clarify the meaning of the term “STEM”. This acronym stands for Science, Technology, Engineering and Mathematics and it was first conceived by Judith Ramaley, director of the National Science Foundation, in 2001. However, it is possible to find also previous references to this concept during the 1990s, when it was called SMET (Donahoe, 2013).

Although from the simple “extension” of the acronym, it may convey the impression of a straightforward interpretation, this is not the case. Firstly, the term can be associated with multiple concepts, both in educational and occupational perspectives, which are broader than the simple reference to the field. Secondly, also shrinking the meaning to “STEM as a field”, numerous classifications of what disciplines enter into this definition have been created in the past 20 years by different subjects.

For what concerns the first issue, it is possible to refer to the definitions provided by Hasanah (2020). In this study, the author identifies four “key definitions” of STEM:

- STEM as Discipline: which concerns the choice of how and what STEM disciplines to teach at the school level;
- STEM as Instruction: which refers to a particular student-centred teaching method that involves problem-solving through the application of science, technology, engineering and mathematics;
- STEM as Field: which involves all the academic and university-related aspects, including the definition of the courses that can be considered “STEM”;
- STEM as Career: which focuses on the occupational definition of the term.

Since this dissertation aims to analyse the relationship between choice of the field of study at university and following employment conditions, it is reasonable to exclude the first two definitions and consider particularly the third and the fourth one.

Despite this specification, it is still essential to address the problem of the identification of the university courses and the career paths which are considered as STEM. The absence of a unique classification raises many problems in the investigation of STEM-related phenomena, and this is also true for the topic of gender differences in this field. An example is the one reported in the study conducted by Manly et al. (2018) in which the authors compare women's college attainment using different definitions of STEM. The results show that the gender gap in degree completion varies substantially depending on the considered operationalization. Moreover, the difference between women and men is not even always in favour of men (even if in most cases it actually is). For example, using a broad definition that includes also social sciences, the percentage of college degree holders is similar, whereas taking into account only science and engineering-related fields, there is a greater representation of women (Manly et al., 2018).

This process of clarification is paramount, not only for research and analysis purposes but also for policy decisions. The lack of a well-defined framework to which policy actions can refer leads indeed in many cases to ineffectiveness or frauds by whom exploits the ambiguity for self-interest (Donahoe, 2013).
A possible solution to this problem is to compare a number of different definitions from universities, government organizations, papers and books. Based on this, it is possible to compute, for each educational programme or occupation, the probability of being defined as STEM and, therefore, to categorize them into high-, medium- or low-frequency STEM (Koonce et al., 2011). However, also using this approach many interpretation complications may arise, because of the freedom given to researchers and policymakers.

A more effective alternative to this approach, for what concerns education, is using the International Standard Classification of Education: Fields of education and training 2013 (ISCED-F 2013) published by the UNESCO Institute for Statistics and available at the following link http://uis.unesco.org/en/topic/international-standard-classification-education-isced (UNESCO Institute for Statistics [UIS], 2015). It classifies the courses in different fields, enabling researchers and policymakers to define uniquely the STEM fields.

With reference to Italy, the MIUR adopted this classification to create a table in which the "Classi di laurea" are distinguished between STEM and non-STEM (which can be found at the following link http://dati.ustat.miur.it/dataset/dati-per-bilancio-di-genere/resource/3f52db2f-24ce-4605-8e51-5618cc4ff4e3; Ministero dell'istruzione dell'università e della ricerca [MIUR], n.d.-b).

Regarding occupations, a classification at the international level is the International Standard Classification of Occupations - ISCO-08, 2012 published by the International Labour Organization (International Labour Organization [ILO], 2012); https://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm
Relying on this publication, ISTAT created an Italian version of this classification called Classificazione delle professioni CP2011 (available at: https://www.istat.it/it/archivio/18132; Istituto nazionale di statistica [ISTAT], 2013).

2.2 *Stylized facts*

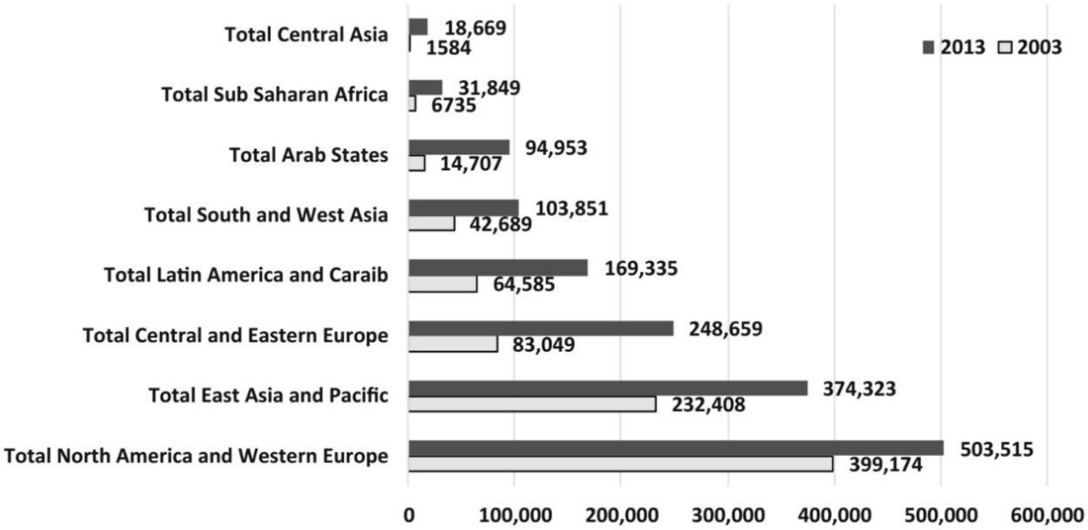
In order to understand the link between the situation in the job market and the choice of a STEM course for women, it is reasonable to first have an overview of the current gender composition situation in this field, both in education and in the labour market.

2.2.1 *The situation in education*

From an educational perspective, it is possible to observe a slow decrease in gender segregation in STEM courses during the last decades. As a result of the increasing awareness on the problem and of the actions taken in a growing number of countries, in the period 2003-2013, the women share of all STEM graduates increased from 43% to 48%, with unexpected evolutions especially in the Middle East, North Africa and sub-

Saharan Africa, where the number of women graduating in STEM increased almost two times faster than the overall graduates (Schmuck, 2017).

Figure 2.1 - Total headcount of tertiary graduated women in STEM



Source: Schmuck (2017)

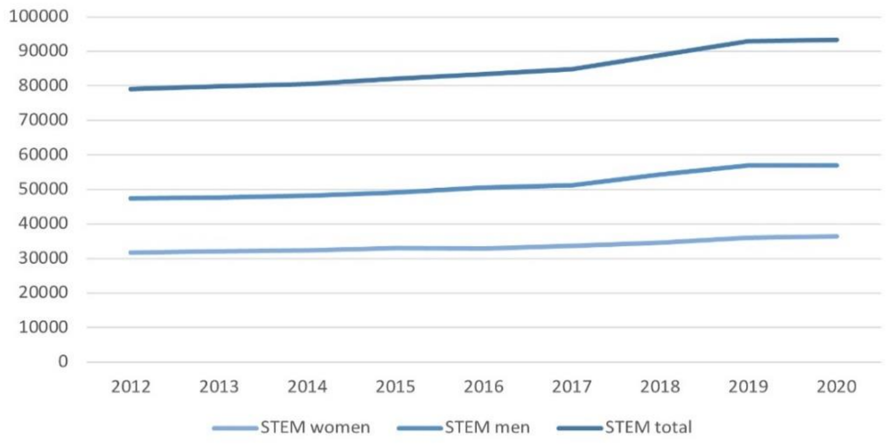
In spite of these encouraging signals, it is important to emphasize that these results change significantly when excluding health disciplines from the count: the increase in the period 2003-2013 was only from 30% to 34%. Schmuck (2017), categorizes regions into three groups:

- Middle East, Africa and South-West Asia: where less than 50% of women who graduated in STEM have chosen health-related disciplines;
- East Asia and Central and Eastern Europe: where the percentage is about 50% in both sub-fields;
- North America, Latin America, Western Europe and Central Asia: where STEM graduated women have chosen for the most part health disciplines.

Reducing the perspective to the European Union, a prominent overview on the issue is offered by the European Commission with “She Figures 2021”, a tri-annual study on gender equality in research and innovation. The report highlights that, even if on average in the European Union there are more women than men between students (54%) and graduates (59%) at bachelor’s and master’s levels and there is gender balance at doctoral level (48%), there are still substantial disparities between sub-fields. In fact, women represent only 22% of doctoral graduates in ICT, while they are the 60% of all doctoral graduates in the health and welfare sector (European Commission - Directorate-General for Research and Innovation, 2021).

Looking specifically at Italy, it is possible to observe an important gender disparity in STEM tertiary education. Evidence of this can be detected in the data provided by the ministry of instruction, university and research (MIUR). These data demonstrate that, even if the total number of STEM graduates increased during the period 2012-2020, girls are still largely underrepresented in these fields, as shown in Figure 2.2.

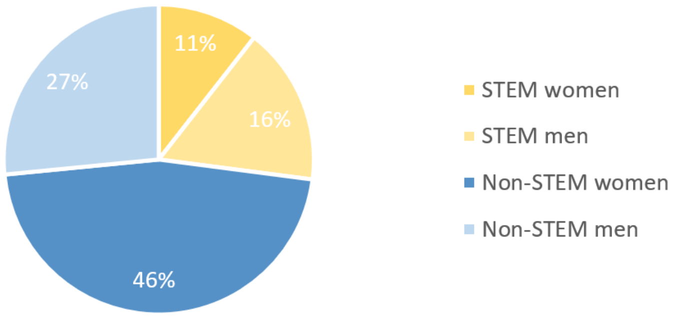
Figure 2.2 - STEM graduates by gender, 2012-2020



Source: our elaboration on MIUR data

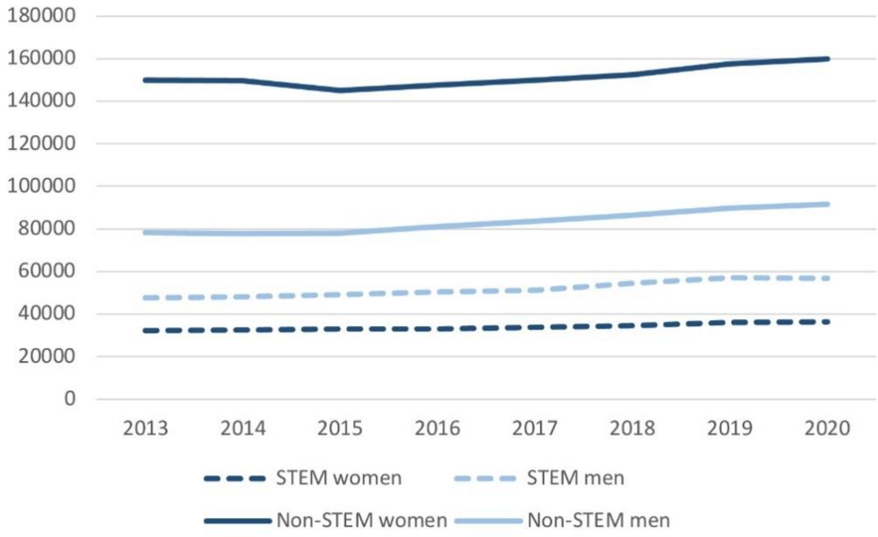
Moreover, Figure 2.3 and Figure 2.4 show that girls outnumber boys for what concerns total graduates, therefore the under-representation does not arise from the fact that there are fewer girls who graduate: there is clear gender segregation (Ministero dell'istruzione dell'università e della ricerca [MIUR], n.d.-a).

Figure 2.3 - Graduates by gender and field in Italy, 2020



Source: our elaboration on MIUR data

Figure 2.4 - Graduates by gender and field in Italy, 2012-2020



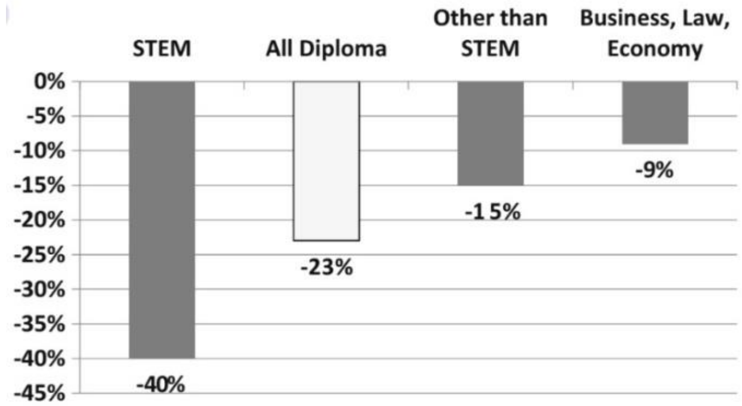
Source: our elaboration on MIUR data

2.2.2 The situation in the labour market

Looking at the labour market, conditions are similar to those in the educational context. On a global scale, it is possible to observe that the proportion of women who work in the STEM fields is much lower than 50%. Differences between the three groups of regions mentioned for education persist in the labour market: while in East Asia and Eastern Europe there is an effective school-to-work transition and the majority of STEM graduated women choose to remain in the field, in the Middle East, Africa and South-West Asia women still face strong discrimination (Schmuck, 2017).

At the same time, the situation in the STEM labour market is affected not only by the school-to-work transition and employment opportunities, but also by the attrition rate, which is the rate of women who drop out of the STEM career. As shown in Figure 2.5, the drop out rate for STEM graduated women is considerably higher than the average and about four times the drop-out rate of women holding a degree in business, law or economics (Schmuck, 2017).

Figure 2.5 – Attrition rate of graduated women by field of specialization

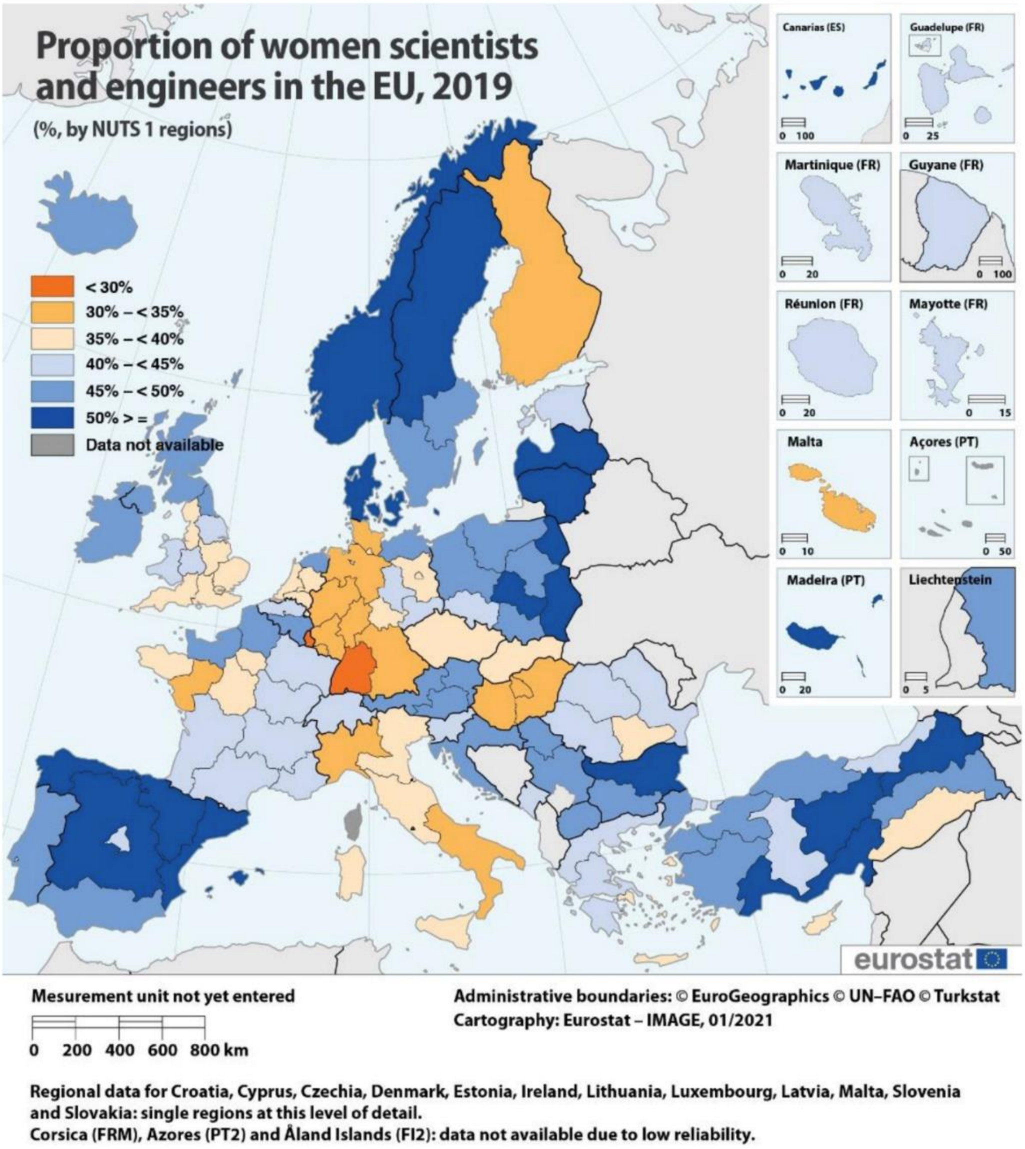


Source: Schmuck, 2017

For what concerns Europe, Eurostat and the European Commission provide some indicators about the participation of women in science and engineering occupations: data suggest that women are both less likely to be employed and are also under-represented as self-employed professionals in science, engineering and ICT (European Commission - Directorate-General for Research and Innovation, 2021).

In particular, in 2019 the female scientists and engineers in EU represented 41% of the total employment. Nevertheless, there were substantial differences both between sub-fields (e.g. female scientists and engineers in manufacturing were 21%, while in services they were 46%) and regions (as shown in Figure 2.6) (Eurostat, 2021).

Figure 2.6 - Proportion of women scientists and engineers in the EU, 2019

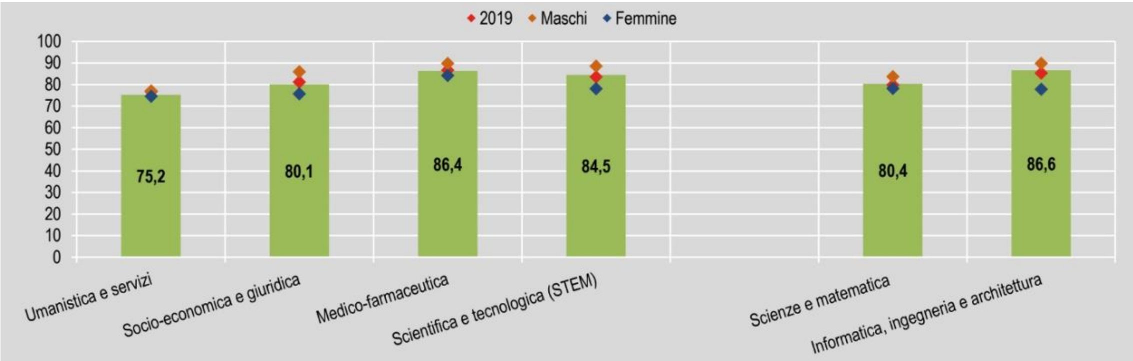


Source: Eurostat, 2021

Relevant gender disparities can also be observed in the academic context, especially when considering the highest levels. This is particularly true in the STEM fields, where the share of women is 35% for grade C academic staff, 28% for grade B and 19% for grade A. Furthermore, there is a gender gap also in the active authorship, especially regarding the fields of natural sciences, engineering, and technology (European Commission - Directorate-General for Research and Innovation, 2021).

In Italy, the situation is in line with the European context: the employment rate of female STEM graduates is 10 points below that of men one. In addition, this evidence does not come only by the fact that women are under-represented in the STEM disciplines with higher employability, because also considering sub-fields separately the gap persists, as shown in Figure 2.7 (Istituto nazionale di statistica [ISTAT], 2021).

Figure 2.7 - Employment rate of 25-64 years old tertiary educated people by field and gender, 2019



Source: ISTAT, 2021

From all of these considerations, the issue of gender segregation in STEM distinctly arises both from educational and labour perspectives.

2.3 *Current policies*

In the past years, persistent gender differences in education and employment regarding STEM disciplines prompted actions from policymakers both at the national and international levels. The rationale behind this necessity is that it is widely recognized that diversity in the research field is essential for innovation and allows the growth of new perspectives (Pietri et al., 2019; UNESCO, n.d.). For this reason, several policies with the aim of promoting women's participation in STEM field were implemented by governments and privates.

UNESCO is one of the organizations which pursue this objective at an international level and, in 2015, its General Assembly established the “International Day of Women and Girls in Science”, celebrated on 11 February.

Nevertheless, this is not the only initiative implemented by this organization, which created also a more practical project with the ambition of providing policymakers with the tools to contribute to reducing the issue. This project is called "STEM and Gender Advancement" (SAGA) and it supported a variety of national and international programs in their effort to contribute to the cause by supplying methodology, data and also training workshops.
Lastly, UNESCO also partners with private institutions and firms. One of the most relevant projects in this context is the collaboration with L'Oréal for the "For Women in Science" programme, which, among other things, awards "five eminent women scientists" from all over the world every year (L'Oréal-UNESCO).

The European Union pursues wider participation of women and girls in STEM fields as well. In particular, in the last decade, this purpose was carried out within the "Horizon 2020" research and innovation funding programme, which funded, among others, also two projects called "Hypatia" and "GENDERACTION".
Hypatia is a programme with the aim of bringing stakeholders (such as schools, museums, research institutions and industries) together in the effort to make the STEM field more gender-balanced through gender-inclusive activities for teenagers. It involved a number of UE countries and ran from 2015 to 2018.
GENDERACTION is the acronym of "GENDer equality in the ERA Community To Innovate policy implementatiON". Its objective is to create a network where more and less experienced countries can exchange ideas to develop knowledge and competencies for gender equality in the research and innovation field. It was operative from 2017 to 2021, especially in Eastern European countries.

For what concerns Italy, the Ministry of Instruction designated March as "Il mese delle STEM" ("STEM Month"), an initiative that involves a competition between schools on projects about prejudices and stereotypes in STEM subjects.
In addition, also universities help reduce the gender gap in science through programmes like "Ragazze Digitali", a summer camp, created by the University of Modena and Reggio Emilia, European Women Management Development Association and the University of Bologna, where high school girls learn to code and participate to other digital activities.

2.3.1 Unintended effects of gender diversity interventions in STEM

The implementation of policy measures like the ones presented in the previous Section has proved to be paramount to address gender biases in science, technology, engineering, and mathematics. When evaluating these policies, it is nonetheless imperative to consider also the potentially negative consequences arising from them. An interesting analysis of these phenomena is the one proposed by Pietri et al. (2018). In their study, the authors conduct three experiments using Video Interventions for Diversity in STEM (VIDS), with the aim of testing three hypotheses:

a) VIDS increase awareness and collective action intention against gender bias and sexism;
b) VIDS act as external social identity threat cues for women (i.e., cues that suggest that women will be devaluated due to their gender identity) and, therefore, decrease the sense of belonging and trust;
c) External identity-safe cues (such as the message that bias can be overcome or a female role model) help mitigate the social identity threat.

The results confirm these hypotheses both for the general U.S. population and for women scientists, leading to some policy advice. The validation of the hypothesis that VIDS may have a negative impact on the sense of belonging and trust of women in STEM fields (hypothesis b) raises concerns about this potential negative outcome of gender diversity interventions. The validation of hypothesis c), however, provides a practical solution to overcome this issue, suggesting combining VIDS with external identity-safe cues in order to reduce the undesired outcomes of these experiments (Pietri et al., 2019).

In conclusion, the advice for policymakers and researchers is to acknowledge the potential unintended effects of their particular gender diversity intervention and to design strategies to address them.

3 Review of literature

3.1 The link between labour market and STEM choice

One of the main reasons why young women tend to avoid STEM when choosing their tertiary education path is the entrenched beliefs about gender roles and suitability for studying and working in the STEM field. These prejudices emerge, among other things, in labour-related mechanisms both on supply and demand side.

On the one hand, social norms discourage girls from pursuing a STEM degree, suggesting that they are not suited for STEM jobs. This creates a lack of supply in women labour force in this field.

On the other hand, several studies demonstrated the presence of barriers in the work environment linked to the concept of the "ideal worker", which can be better emulated by men because of the expectations that women have to face in terms of housework and childcare. This results in a number of issues on the demand side of the labour market, such as gender disparities in hiring, pay and promotion processes (VanHeuvelen & Quadlin, 2021).

All of these mechanisms intertwine in the STEM labour market, creating an unappealing framework for women and, therefore, generating the unbalanced situations in education and labour market described in the previous chapter. For this reason, the aim of this Section is to analyse the barriers women have to face during their career in STEM and their perception of the experience of studying and working in such a male-dominated environment.

The barriers a woman has to address when she takes the decision of pursuing a STEM career are numerous and of different nature, but this "burden" remains a constant through all of the career stages.

The major barriers at early stages are lack of mentorships and lack of female role models. For what concern later phases, unequal growth opportunities and gender pay gap become always more relevant.

An additional critical point is the work-life balance, which becomes an actual issue for women who are considering pregnancy and motherhood. In order to help fixing this problem, some companies adopted flexible work policies, but this often results in negative consequences or penalties for women who adhere (Botella et al., 2019).

Nevertheless, besides actual issues faced by women in STEM, a primary role in this analysis is played by the perception of these issues and of the working environment in general that young women have.
A recent study involving interviews and discussion in focus groups composed of female STEM professionals finds that women perceive that these barriers affect women, while are simply non-existing for men. Furthermore, this study allows to identify and categorize challenges experienced by women in categories like double standards, underestimation, isolation, objectification, etc. (O'connell & McKinnon, 2021).
All the results of this qualitative analysis are focused on the perception women have of this environment and, therefore, it is plausible that girls who are choosing university majors may share this perception and be affected by it in their decision.

In the following Sections, some of these labour-related issues and their link to girls' educational choices will be investigated in more detail.

3.1.1 The gender pay gap in the STEM field

Researchers widely investigated the causes of major choice by high school students and many studies focused also on the relationship between expected earnings and the probability of choosing a particular field.
The outcomes of these studies show that expected earnings, together with abilities and other non-pecuniary factors, are important determinants of schooling choices (Arcidiacono et al., 2012; Beffy et al., 2012). In particular, in their study on the French post-secondary education system, Beffy et al. (2012) develop a model in which both earnings and non-monetary factors are included, and they find a low but significant elasticity of major choice to expected earnings.
This question is not a recent topic in economic literature: Berger (1988) links the choice of the major to future earnings, placing particular attention on what aspect of earnings influences this decision. In his analysis, based on a life-cycle model approach, the author

demonstrates that a major role in this context is played by the present value of the stream of future earnings, rather than the beginning or average earnings.

More recent studies, however, concentrate on the fact that students' information about labour market outcomes is significantly inaccurate (Arcidiacono et al., 2012; Baker et al., 2018).

Baker et al. (2018) analyse this topic in the context of community colleges, where students tend to have lower incomes and lower GPAs. They examine data coming from a survey administered at different disciplines classes in two community colleges in California's Bay Area in the winter of 2014. In this survey, students were asked about their knowledge of labour market outcomes in different fields and the answers were compared to the real-world data from the California Employment Development Department (EDD) Labor Market Information Division to assess students' estimates accuracy. The authors find that on average, students overestimate salary by 13.5% and underestimate both the probability and stability of employment, by 24% and 4.3% respectively. The same study detects an association between estimated salaries and the probability of choosing a major, which becomes stronger when students are provided with information about salary. The explanation given by the authors for this difference is students' ambiguity aversion. When students do not have information, they tend to choose majors with more certain outcomes (i.e., major whose salary and employment possibilities they feel they can predict with greater confidence), even if the expected salary is not particularly high. Once information is provided, the ambiguity is reduced and the choice depends more on salary, generating the results observed before.

In any case, future earnings (real or perceived) appear to be an important determinant of post-secondary education decisions, as predicted by the human capital theory, which considers them as the benefits of educational choices. For this reason, the presence of a gender pay gap in the STEM field may be relevant to this analysis.

Studies show that earnings differences between women and men are especially pronounced in STEM occupations, such that the penalty for women over the first 10 years of career is equivalent to a one year's salary (VanHeuvelen & Quadlin, 2021).

Human capital theory suggests that this gap may arise from lower human capital accumulation, but STEM graduated women's and men's GPAs in their undergraduate majors (which can be interpreted as human capital stock at labour market entry) are similar. Moreover, the disadvantage cannot be explained either by lower human capital accumulation due to women's familiar obligations, since the earning gap occurs also between childless unmarried men and women (Xu, 2015).

A peculiar point of view on the gender pay gap in STEM field is the fact that earnings can be influenced by the share of women in the field. Michelmore & Sassler (2016) test the hypothesis that increasing the presence of women may tip the occupation to a predominantly female occupation and subsequently devalue (or pollute) the field, thereby resulting in lower wages for all the individuals within the field. To test this devaluation theory, the authors use a dataset that comes from the National Science Foundation’s (NSF) Scientists and Engineers Statistical Data System (SESTAT). This system comprises three ongoing surveys designed to create a nationally representative sample of science and engineering college degree holders and the authors considered six waves of these surveys from 1995 to 2008. They run OLS regressions of the logged wages on the lagged share of women working in each specific STEM occupation, separating them also by ethnic group. They find significant increases in wages associated with a higher women concentration in life science and engineering, while they find some evidence (although not all significant) in support of the devaluation theory in physical sciences and computer and mathematical sciences. This relationship is relevant in the context of tertiary education decisions because there can be a spurious correlation between expected earnings and gender composition, which in turn depends also on gender differences in STEM major choices.

Returning to the effect of expected earnings on girls’ STEM field degree choice, there is, however, another important aspect to consider. All the studies presented before base their results on data relative to the entire population of students, without gender distinctions. In a study conducted on the Chinese system by Ding et al. (2021), this issue is exanimated through a wage informational intervention. In China each year in June, students take the National College Entrance Examination (CEE) in one of two tracks, STEM or non-STEM. Then, students create a college-and-major preference list and college admissions are determined by their CEE scores and their preferences. The authors partnered with the Department of Education in Ningxia Province to implement, in 17 randomly selected schools in three randomly selected cities, a survey which collected information about

students' college major beliefs and preferences. They then implemented an information intervention in which students were presented with information about the first-year post-graduation average wage by major (using data from the National Survey of College Graduate Employment by Peking University). Finally, the authors asked the students to complete another survey in which they had to indicate their updated major preferences. The authors find that, before they provide information about wages, girls are less likely to prefer STEM majors. After the informational intervention, 39% of students change major preferences, but females are about 50 percent less likely than male students to switch from a non-STEM major to a STEM major, demonstrating that girls tend to be less responsive than boys to wage information and, more in general, to monetary incentives. Evidence about this issue is provided also by Zafar (2013), who finds that non-pecuniary aspects explain about 45% of choice behaviour for men and 75% for women.
For these reasons, the following paragraphs will investigate in more detail other less pecuniary-related aspects of the STEM working environment that may affect girls' major decisions.

3.1.2 The glass ceiling and the glass cliff effects

Career advancement and promotion to higher levels of the corporate hierarchy are two paramount elements of the working environment and, hence, they are two factors that high-school students may take into account when choosing tertiary education paths. When considering this aspect, it is plausible that girls notice the presence in the STEM field of the so-called "glass ceiling effect". This effect refers to a variety of difficulties that women and other minorities face, preventing them from reaching leading positions inside an organisation. For girls who have career aspirations, this is obviously a problem and the presence of this effect in the STEM sector may inhibit their intentions to pursue scientific studies.
An essential point to highlight is that this process does not start at advanced career stages. Instead, evidence shows that signals of the glass ceiling effect occur already during schooling years. In an experiment conducted by Moss-Racusin et al. (2012), science faculties are asked to rate application material for a laboratory manager position with randomly assigned male or female students' names. The results show that faculty participants view female students as less competent and less hireable than males. Women

are also offered less career mentoring and lower starting salaries, independently of faculty participants' gender. The authors link these behaviours to a "pre-existing subtle bias against women" and claim that diminished competence judgements at such an early stage may increase the probability that girls opt out of science careers.

For what concern training environments, it is possible to notice that there is a tendency for gender separation in teams, which can be caused both by women's choice and external factors of segregation. However, there is no evidence of clear gender issues in the training environment (Buffington et al., 2016).

Another critical point occurs at the entry in the labour market. The first leak of the so-called "leaky pipeline" of the school-to-work transition in STEM sectors is that many female STEM graduates decide not to pursue a career in a STEM occupation, due to its disadvantages and unsupportive culture. Evidence on this can be found in the high attrition rate from college to employment of women in STEM: 22,4% of STEM graduated women work in occupations unrelated to their degree, compared to 15,7% of men (Xu, 2016).
Even when women decide to pursue a STEM career, a pattern of gender separation in different occupations appears already at this initial stage, with men that are more likely to enter the lucrative sector of industry and women that are more likely to work in academia and government (Buffington et al., 2016).
Furthermore, studies show that STEM female graduates are less likely to obtain a highly-skilled STEM job than male graduates (20% compared with about 33%) during the first six months of their career. This gap is larger in the more male-dominated STEM sectors (e.g., engineering and computer science) and smaller in the less male-dominated fields (e.g., physical and biological sciences).
In addition, it is less probable for women to access managerial and professional positions rather than lower status Associate Professional jobs, both compared to male STEM graduates and female non-STEM graduates (White & Smith, 2021).

All these issues at early professional stages are the first signals of the glass ceiling effect that young women will face while progressing in their careers. In later phases, the

professional path of women in STEM is, indeed, as challenging as in initial ones. Some of the problems are, nonetheless, different and, particularly, they are more related to relationship with peers and leadership.
Studies show that STEM women tend to place importance on social support, which is a crucial element for the perception of workplace and career advancement (Amon, 2017). Nevertheless, the typical STEM workplace lacks this feature and creates an inhospitable environment for women, which often report isolation, a “boys’ club” atmosphere and even being regarded as an anomaly or a problem by their colleagues (Rosser, 2004).
Another frequently reported issue linked to career advancement is the pressure of balancing work and family. This is a particularly hard task for women due to their stereotypical role in raising children, and at the same time, it is an essential aspect for gaining credibility and respectability from peers (Rosser, 2004).
Despite these challenges, many women manage to climb the corporate ladder and reach leadership positions inside their organisations. Also at this point, however, they deal with barriers that decrease job satisfaction. Firstly, women in leadership positions perceive a lack of authority and tend to build legitimacy by fostering positive relationships with their subordinates. Secondly, female leaders are also vigilant about colleagues’ evaluation of their behaviour, in particular when gender dynamics (and therefore, gender stereotypes) are involved (Amon, 2017).

In an effort to explain this discrimination against women in male-dominated environments like the STEM field, Garcia-Retamero & López-Zafra (2006) consider the idea of “gender role congruity”, which pertains to the association between some characteristic and a specific gender. For example, stereotypically men tend to be associated with power, competition and authority, while women tend to be linked to roles that involve human interactions. To conduct the study, the authors recruited 705 individuals, depending on their age and sex, and divided them into six randomly selected groups. They then asked the participants to complete a questionnaire in which they had to evaluate male or female candidates for leadership positions in industries that were congruent or incongruent (depending on the group participants were assigned) with their gender roles. The results show both advantages and disadvantages for women in leadership positions. On the negative side, in male-dominated sectors, participants perceive women as less likely to be promoted or to be potential leaders. They also expect lower performances of female candidates compared to male ones and they attribute the cause of promotion of women to external causes (e.g., broadening of the staff) and for men to internal causes (e.g., personal capacity). On the positive side, instead, participants recognize that female leaders tend to have a better, more “transformational” leadership style, which involves more cooperation, establishing oneself as a role model and providing support to subordinates. This characteristic can be considered a possible advantage for women in leadership positions because it can improve people’s evaluation of the leader.

Another effect, which is closely related to the glass ceiling effect, is the glass cliff. It refers to “the tendency for women to be more likely than men to be appointed to leadership positions that are risky and precarious” (Ryan et al., 2016). This is another barrier to the advancement of women in later stages of their STEM careers. This relatively widespread dynamic arises in presence of risks of different nature.

Firstly, several studies show that in times of crises and poor company performance, women tend to be promoted to leadership positions more than in the case of stable company performances. This process arises both because appointing a female leader is a signal of change (which is regarded as positive during crises) and because women’s leadership style is (stereotypically) perceived as more suitable than men’s one (Ryan et al., 2016).

Furthermore, another form of glass cliff effect occurs when the precariousness is due to the working environment. The lack of support from their teams and acknowledgement from their superiors, the insufficiency of resources and the ineffectiveness of networks put women in a position of uncertainty and risk, especially when they are at higher levels of the corporate hierarchy (Wilson-Kovacs et al., 2006).

When a woman finds herself in these two situations, she is particularly exposed to unfair and severe judgements even regarding processes that started before her promotion to a leadership position (Ryan et al., 2016; Wilson-Kovacs et al., 2006). Hence, the presence of the glass cliff effect in the STEM sector may have a negative impact on women’s experiences in this field and it may be an additional signal that discourages girls in their decision of studying science, technology, engineering and mathematics.

3.1.3 The Matilda effect

The issues faced by women who pursue a STEM career are not limited to the business area. Also, when women choose an academic professional path, they have to deal with discrimination based on their gender. One relevant topic in this context is the "Matilda effect", which consists in the fact that women are systematically under-recognized for their contributions to research in favour of their male colleagues (Rossiter, 1993). The concept derives from the "Matthew effect", which is the effect for which eminent scientists get disproportionately great credit for their contributions to science while relatively unknown scientists tend to get disproportionately little credit for comparable contributions (Merton, 1968). Rossiter (1993) notices that this phenomenon is particularly common among female scientists and that it is not only a question of fame, since not only have those unrecognized in their own time generally remained so, but others that were well-known in their days have been obliterated from history.

The Matilda effect impacts meaningfully the potential professional growth of female researchers because tenures and promotions in academia are closely linked to publications. For this reason, it may play a relevant role in the decision of studying a STEM subject at university for the girls who want to undertake an academic career.

There are several occasions in which the Matilda effect emerges. Firstly, for what concerns publications more strictly, studies show that male authors' publications are perceived as higher-quality and collaboration interest is higher for male authors. These results are particularly true if the topic is male-typed, as often STEM topics are, and therefore, in line with the role congruity theory described in the previous section (Knobloch-Westerwick et al., 2013).

This disparity in the perception of male- and female-authored contributions, may also be one of the causes of the gender productivity gap among star performers in STEM. In particular, Aguinis et al. (2018) focus on this portion of researchers because star performers are often highly influential and produce greater output than others. For this purpose, the authors conducted three studies analysing the productivity (measured as the number of articles published in top journals) of star performers in mathematics, genetics and psychology. In this study, researchers are defined as star performers if they published at least one article in one of the ten (for mathematics) or five (for genetics and psychology) most influential field journals from January 2006 to December 2015. The choice of the journals is based on the average number of citations received per article published in the journal during the two preceding years. The final samples are composed of 3853 mathematics researchers, 45007 genetics researchers, 4081 applied psychology researchers and 6337 mathematical psychology researchers. Results show a stronger underrepresentation of women among star performers than among all performers and this disparity grows when levels of performance increase (e.g., from the top 5% to the top 1% of performers). This effect is attributed to the interaction between the accumulation of productivity components (e.g., scientific knowledge, resource, social capital, networks) and gender discrimination. In particular, the study found that even if a female star researcher accumulates the same productivity components as her male colleagues, she will experience smaller increments in productivity due to gender discrimination mechanisms. This highlights a crucial policy implication: giving women more opportunity and resources is not enough if these gender biases continue to operate.

One of the possible actions to reduce this effect is to replace the single-blind review system with a double-blind review one for papers published in STEM journals. This practice consists of a peer review in which both author and reviewer identities are concealed and, hence, the perception of the contribution cannot be influenced (consciously or not) by factors like gender or country of origin. Studies show that the implementation of this policy increases significantly the portion of papers with a female first author, consistently with the idea that there is a gender bias in the case of single-blind reviews (Budden et al., 2008).

Another manifestation of the Matilda effect is the tendency of attributing the successful performances of teams to male members rather than to female members. This aspect is important because of two facts:

a) Research work is increasingly done in teams;
b) In STEM field, since there is a lower representation of women, female researchers are more likely to work together with men than with other women.

Evidence shows that, unless the ambiguity about the individual team member’s contribution is excluded or unless there is clear evidence of prior work competence, female researchers get poorer evaluation compared to male members. In particular, women tend to be perceived as less competent, less influential and less likely to have taken a leadership role. Studies, however, show that the problem is not the teamwork, but the ambiguity of the contribution and the prior expectations on women's performances in male-dominated fields (Heilman & Haynes, 2005). Thus, the problems are once again the discrimination and the gender biases.

Finally, the last example of the Matilda effect is the proportion of awards and prizes won by women compared to men in STEM. These elements are as crucial as publication in determining the advancement of academic careers and, hence, the underrepresentation of women among scholarly awards winners is another signal of the disadvantages women have to face in this male-dominated field.

The bias against female researchers is noticeable from the first stage of the rewarding process. In the stage of call for nomination, prizes criteria are often described with terms that are stereotypically associated with men (e.g., leader, person who takes risks) and this, combined with the beliefs of differences in capabilities of women and men, discourages women from self-promoting.

Once the nomination phase is completed, concerns regard the composition of the award committee. Studies show that the presence of women in committees increases significantly the probability of a woman winning the prize. However, this effect is nullified when these committees are chaired by men, and in this case, is also much more likely for male researchers to receive the prize compared to the case of female-chaired committees.

In the STEM fields, the combination of these two issues results in a smaller percentage of research awards won by women compared to men, who, in general, are twice as likely to receive a prize regardless of their representation in the nomination pool.

Another controversial aspect of credit recognition is the women-only awards. On the one hand, they were created with the aim of reducing gender bias and highlighting female researchers' contributions. On the other hand, they tend to marginalize and devaluate women's scientific contributions compared to men's ones. Furthermore, they inflate the count of total female award recipients, hiding the disparities of awards for both genders, especially in fields in which women are strongly underrepresented.

For these reasons, it is not sufficient to improve women's representation in the nomination pool or to create designated awards: actions to eliminate the gender biases and the stereotypes of the committees (for example through a more gender-balanced committee composition or prior information of committee members about these topics) are crucial to overcome the female underrepresentation in this context (Lincoln et al., 2012).

3.2 Other factors that influence the major choice

Occupational perspectives are not the only element that determines the choice of studying science, technology, engineering, and mathematics at university. A number of personal, environmental and behavioural factors during secondary school and university years play an important role in this decision and several studies attempted to investigate this relationship. For what concerns personal aspects, parents and family characteristics (e.g., education level, marital status, socio-economic status), together with academic performance, are key determinants of the student's major choice. Regarding behavioural factors, self-efficacy is strongly associated with the probability of enrolling in STEM degrees at university and the lack of it among high-school female students can be considered one of the root causes of their underrepresentation in science courses. The issue of the lack of self-efficacy is also strictly connected to environmental factors, like the cultural beliefs and gender norms that depict women as not suitable for STEM field and not skilled enough for it. Moreover, these stereotypes can be reinforced or weakened by the lack or the presence of parental, teachers and peer support, and this is particularly true for girls, who tend to be more sensitive to the interpersonal aspects compared to boys (Tandrayen-Ragoobur & Gokulsing, 2021).

Other studies focus more on the institutional aspect of the high-school system as a determinant of the gender gap in STEM education and occupation. In particular, a crucial feature of an education system is the stratification, which refers to the degree to which students are sorted into separate school types with clearly differentiated kinds of school curricula (e.g., academics versus vocational schools; Han, 2016). Evidence shows that a stratified education system is negatively associated with girls' STEM-related occupational expectations and, therefore, with their STEM major choice.

A peculiar idea is the concept of STEM readiness developed by Card & Payne (2021). The authors claim that STEM entry for both genders depends on STEM readiness, measured as the completion of at least three STEM-related classes in the last year of high school. In this framework, the gender gap in STEM majors enrolment is a result of a lower fraction of STEM-ready female students compared to males, a lower fraction of STEM-ready females who enter university, and, above all, a higher fraction of non-STEM-ready girls who are university ready. In other words, the gender gap in STEM is a reflection of the lower rate of university entry of men (especially in non-STEM-related fields).

Likewise, the occupational factors analysed in the previous section, also in this area there is not a single determinant of the underrepresentation of women in STEM. All of these possible explanations intertwine (also with labour market factors), making it difficult to identify the key aspects to consider in the process of policymaking.
In the remaining part of this Section, the focus will be on peer effects and teacher composition, two essential school-related aspects that greatly affect tertiary education decisions.

3.2.1 Peer effects

Interaction with other peers shapes significantly the behaviours and the preferences of individuals, especially during crucial stages of life like adolescence.
In this period, the group of peers that matters the most are classmates, both because students spend a lot of time in school and because they are people of the same age and in the same situation. Regarding the choice of studying STEM, a relevant role in this context is played by same-gender others' behaviours, because adolescents tend to adhere to gender roles and sanction those who do not. Specifically, the more female classmates have nonconforming gender preferences, like the predilection for STEM subjects, the more a girl is likely to retain her STEM preferences. This mechanism can protect girls from sanctions against non-gender-conforming behaviours and thus prevent them from abandoning the STEM career option at this early stage.

Nevertheless, there is a sub-group of classmates, that is close friends, that contributes even more to shape preferences and behaviours of a person. Their relevance emerges because of two mechanisms:

a) social influence: friends tend to influence one another;

b) friend selection: people tend to befriend similar people.

These two elements result in the fact that students tend to adopt their friends' subject preferences, and this is a crucial aspect to consider when analysing the underrepresentation of women in STEM. In particular, since girls are less likely to select a STEM subject as their favourite, the mutual influence in a group of female friends promotes the preference for non-STEM fields (Raabe et al., 2019).

Friendship cannot be controlled by policymakers and, therefore, it cannot be used as a tool to reduce the STEM gender gap. There are, however, other aspects of peer influence that could be considered as potential instruments to reach this objective. One of them, which has been widely investigated in the past years, is high-school classes' gender composition. Ideally, it could be a powerful tool for policy actions, because of the possibility of determining the ideal proportion of male and female students to improve their performances and reach desired outcomes (like a higher share of girls enrolling in a STEM program at university). Scholars, however, do not agree on the sign of the effect of class composition on major choice and different studies show evidence that supports both the hypothesis of positive and negative impact of a higher rate of female or male students (Anelli & Peri, 2019; Brenøe & Zölitz, 2020; Lavy & Schlosser, 2011).

Park et al. (2018) analyse the effect of single-sex schools on math test scores, students' interest and self-efficacy in math and science and choice of a STEM major at university. They find a positive effect on all of these variables for what concerns all-boys schools' students compared to their coeducational schools' peers, but they do not find anything significant about all-girls schools' students. The authors suggest a possible explanation: boys tend to have higher expectations of STEM college majors and thus their interaction increases their interest and self-efficacy and enhances their math scores; on the contrary, girls tend to have lower expectations of STEM college majors and hence these peer effects are weaker for them.

A contrasting view is the one of Brenøe & Zölitz (2020), who examine Danish administrative data about the entire population of first-year high school students enrolled in the math track from 1980 to 1994. Linking this data to annual data on educational enrolment and degree completion, they are able to follow individuals in their education and labour market outcomes over the curse of 20 years after high school entry, making it possible to examine their university major choice. The authors study these data including in their analysis school fixed effects, cohort fixed effects and school-specific time trends, to make plausible the assumption that the variation in the peer composition is exogenous once controlled for these effects. They find that a higher share of female peers makes both men's and women's initial choice of study field and field of graduation more gender stereotypical. The study shows that a 10% increase in the proportion of female peers lowers girls' probability of enrolling in STEM degrees by 1,4% and increases boys' probability by 0,9%. One possible explanation is the fact that while women's preparedness to enter STEM studies (measured using GPAs) is not affected by class gender composition, men tend to achieve higher GPAs in classes with more female peers. For this reason, in these classes, boys may feel better prepared for STEM studies and the comparison with their female classmates may lead girls to feel less prepared or suited to study STEM at university.

A potential source of this ambiguity in the results is the heterogeneity of the effects. Pregaldini et al. (2020) analyse how preferences for STEM field affect the effect of classroom gender composition on math grades of girls in high school. The authors analyse administrative data from internal records of a gymnasium (i.e. academic high school) in Zurich, that provide individual-level information about all students enrolled in the high school from September 2002 through June 2012. In the Swiss educational context, students, before entering grade 9, have to choose a specialization among STEM, modern languages and ancient languages and then they are randomly assigned to classes within the chosen specialization. This randomized mechanism of class formation and the large dimension of the school (approximately 2300 students) allow the authors to consider this context a natural experiment in which the variation of the classroom gender composition is exogenous to students' ability within specializations. The results show a positive effect of a higher proportion of female students on math grades for students (both male and female) who have self-selected into a language specializations, while a negative effect for girls who self-selected into a STEM specialization. The fact that STEM female students perform better when the proportion of boys is higher can be attributed to differences in willingness to compete. In general, boys tend to be more competitive than girls and students with STEM preferences tend to be more competitive than other students. For these reasons, girls in STEM specialization may benefit from a more competitive environment (i.e., a class with a higher proportion of boys), whereas girls in language specialization may benefit from a less competitive environment (i.e., a class with a higher proportion of girls). Hence, the major implication of this study is that “no one-size-fits-all solution exists for the optimal gender composition of classrooms”.

Heretofore the only aspect considered was the quantity of female and male peers. It is nonetheless essential to inspect also how the quality of peers affects the choice of studying STEM. Mouganie & Wang (2020) find that, while boys are not affected by this kind of peer effect, girls’ exposure to high-performing female peers increases the probability of choosing a science track during high school and vice versa for exposure to high-performing male peers. High exposure to well-performing female classmates may indeed provide a role model for other students and undermine gender stereotypes, encouraging girls to undertake a STEM career.
On the other hand, this positive impact is not persisting at university. In this context, the probability that a woman graduates with a STEM degree decreases when the proportion of higher ability peers (both female and male) increases, while men are not affected by it. Moreover, this effect is higher for girls in the bottom third of the math ability distribution, who are most at risk of dropping out of STEM. A plausible mechanism that causes this response are grades. Women tend to be more responsive to grades than men and the class ability composition influences the grading system and thus the grade received by a student. If there is a higher share of high-performing peers, grades may be lower compared to the case of a lower share of high-performing students, affecting students’ self-perception and leading those with a lower ability (in particular girls) to switch to other majors (Fischer, 2017).

In conclusion, the effects of both gender and ability peer compositions on the girls’ choice of studying STEM are still not clear and evidence suggests that there may be heterogeneous effects that led previous studies to different findings.

3.2.2 The role of teachers

Teachers are a reference point during adolescence and their characteristics, behaviours and beliefs have the power to shape those of their students. They indeed have a primary role in teenagers’ development, not only from the academic point of view but also for what concerns the evolution of their beliefs and behaviours. For this reason, it is paramount to analyse if teachers' characteristics affect or not the decision of choosing a STEM major at university and starting a STEM career.

For what concerns secondary school, studies point more or less in the same direction: high-school teachers are influential in students' decision of studying in a science-related field (Bottia et al., 2015; Dee, 2007; Key & Sass, 2019; Sansone, 2019).
Their influence starts from the weakening of the gender stereotypical beliefs about science and math. Sansone (2019) analyse data from the HSLS:09, a US nationally representative panel micro dataset, which includes information about 21440 students in grade 9 from about 940 schools. This dataset is the result of a set of surveys administered between 2009 and 2013 to randomly selected students and their parents, teachers, school administrators and school counsellors. Using these data, the author studies how the math and science teachers' gender impact students' beliefs about these two subjects and their willingness to enrol in advanced courses of these subjects while in high school. Results show that having a female math or science teacher reduces the probability of thinking that men are better than women in these subjects by almost 6% for female students, and in this case also male students are less likely to hold negative gender attitudes. This is a crucial aspect because girls who believe that men are better than women in math or science are less likely to take advanced courses in high school and hence tend to be less prepared for a future STEM degree.
Evidence also shows a relationship between the gender composition of high-school faculty and the decision (or at least the intention) of majoring in STEM fields. Attending a school with a higher proportion of female math and science teacher is associated with an increase in the probability of declaring and graduating with a STEM major for girls, while having no relation with boys' major decision. This effect increases for high-skilled female students because, since their ability in math and science is high, they tend to be more sensitive to other factors' influence (beyond ability) in their choice to major in STEM (Bottia et al., 2015). This impact of teacher gender composition on educational choices is caused by two mechanisms, teachers' passive and active representativeness. First, female math and science teacher are passive representatives since they signal to female students that those fields are suitable for them, acting as role models and

interrupting the cognitive association between STEM success and masculinity. Second, female math and science teacher tend to have a higher subjective evaluation of their female students and encourage them more, thus acting as active representatives (Stearns et al., 2016).
According to Sansone (2017), however, the second mechanism is the most influential. The author analyses the impact of teachers' gender, ability, behaviours and expectations on students' interest and self-confidence in math and science. For this purpose, he uses the dataset HSLS:09, the same used in his article reported previously in this Section. The results of the analysis show that teachers' gender appears to affect students' interest and self-confidence, but once teachers' behaviours, attitudes and expectations are included as control variables, gender becomes insignificant, highlighting a potential omitted variables bias issue. In particular, he finds that both females and males show less interest when teachers treat them differently and that teachers' beliefs about female and male abilities are a key determinant of students' confidence and interest in STEM. Moreover, he finds that all students are positively affected when teachers value and listen to their ideas, as well as when teachers make their subjects interesting.

As regards university, scholars have mixed opinions about the impact of faculty gender on female and male academic and non-academic outcomes. Canes & Rosen (1995), find no evidence that the gender composition of faculty in an academic department affects the gender composition of the students, even considering time lags.
On the contrary, Bettinger & Long (2005) and Carrell et al. (2010), find that faculty gender has a powerful effect on female students' outcomes, while still having a minor impact on male students' ones. These studies find indeed that female students perform better and are more likely to take advanced courses in math and science-related subjects if during their initial exposure to these subjects at university they face female instructors.
Finally, Solanki & Xu (2018) claim that female professors narrow the gender engagement gap, both because of female students reacting positively to female instructors" and "male students reacting negatively to female instructors.
In conclusion, these effects may depend on the context and the considered variables and thus there are still no clear policy implications.

4 Empirical analysis

4.1 The data

In order to study the relationship between occupational perspectives and the choice of studying a STEM subject at university, I examined the dataset that emerged from the survey "Inserimento professionale dei laureati" ("University graduates' vocational integration") 2015 edition, by the Istituto Nazionale di Statistica (ISTAT). This survey is part of a system of surveys that aims at analysing the school-to-work transition at different levels of education (upper high school graduates, university graduates, and doctorate holders), in order to compare their employment conditions at a certain time after their graduation.

The data refers to the survey conducted in 2015 and the target population is composed of people who graduated in 2011 from one of the 90 Italian universities. It includes:

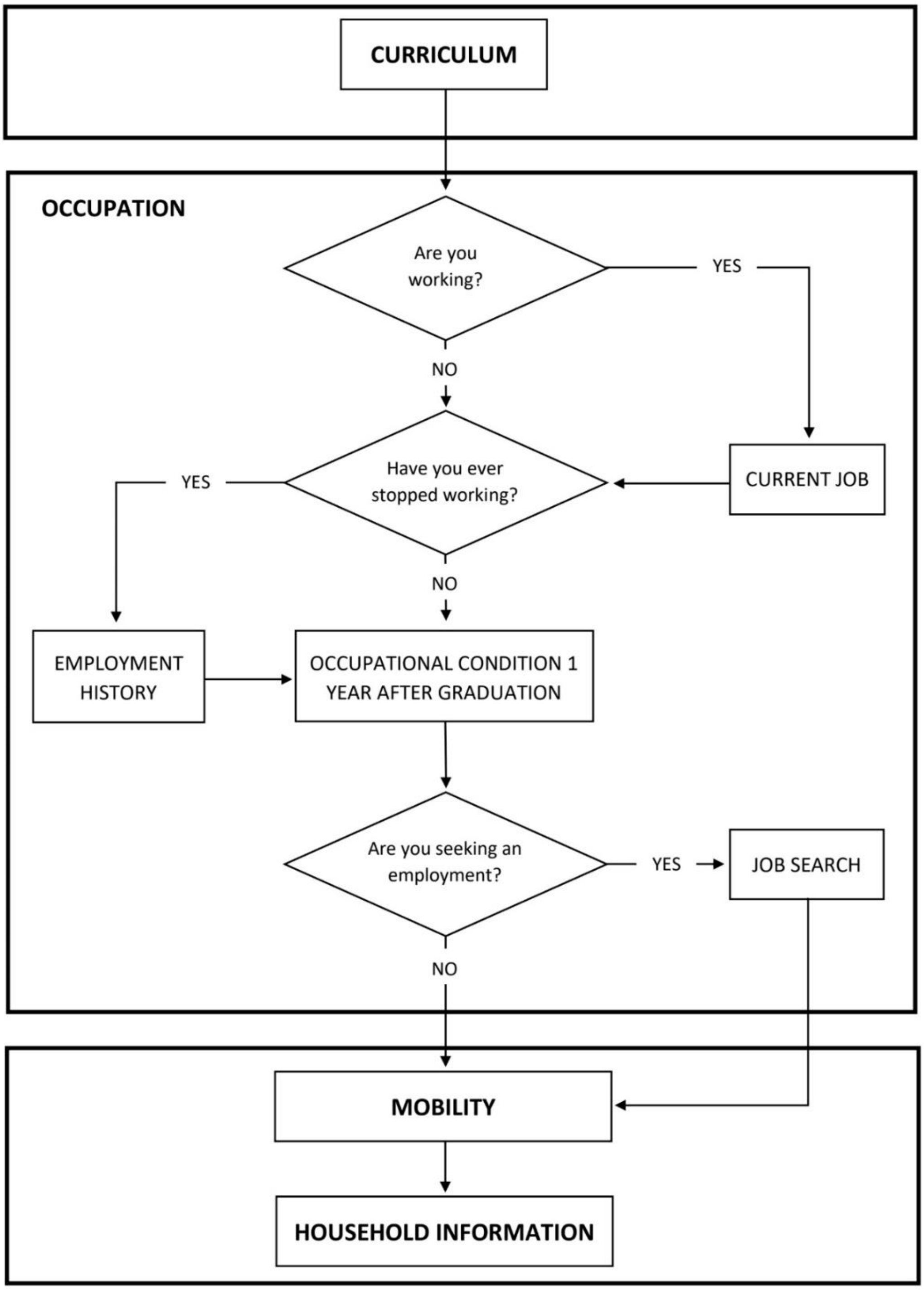
- 169.232 Bachelor's degree holders;
- 43.624 Single-cycle degree holders;
- 86.593 Master's degree holders.

The sampling list was constructed using both the administrative archive of the instruction ministry, "Anagrafe nazionale degli studenti" (Ans2011), and a census conducted by the ISTAT in the ninety Italian universities during the period April-May 2014, to retrieve some information that was missing in Ans2011. The reference population was split into two groups, a) the bachelor's degree holders and b) the master's and single-cycle degree holders, and for each sub-population, ISTAT selected a sample. The samples were selected through two separate sampling designs, using in both cases an "incomplete stratified sampling design".

The survey was then conducted adopting the mixed technique Cawi/Cati. Initially, a sub-sample of 73.825 graduates was invited to complete a web questionnaire (Cawi). During this phase, ISTAT also implemented a system of email and phone reminders for those who were not answering the questionnaire. Then, those who did not answer the Cawi questionnaire and an oversample selected in this phase were contacted for a phone interview (Cati). The overall response rate was 70,2% (Istituto nazionale di statistica [ISTAT], 2016).

The questionnaire was structured as shown in the following diagram:

Figure 4.1 - Sections and nodes of the questionnaire "Inserimento professionale dei laureati"



Source: our elaboration on ISTAT diagram

The variables considered in the empirical analysis are mostly part of the sections:

- "Curriculum", for what concerns educational background and major choices of graduates;
- "Employment history", for what concerns the employment situation of STEM graduates;
- "Household information", for control variables.

Firstly, I considered as dependent variables multiple indicators of the occupational situation, like the employment status, the monthly income earned from the main job and the months between the graduation and the first job. I also considered the perception of this aspect, measured by a variable that indicates the overall satisfaction with the working environment on a scale from 0 to 10. Moreover, in the second part of the analysis, I included a dummy variable that indicates one's willingness to re-enrol in the same degree program, which can be considered an indicator of the willingness of high school students to enrol in a particular degree program. In order to understand deeper the answers, I also looked at the reasons why subjects state that they would not re-enrol. The five causes reported in the questionnaire were divided into three groups: the first related to occupation and work, the second related to the organization and the contents of the course at university and the third linked to a shift in subjects' interest from their field of study to other fields.

Secondly, for what concern the regressors of interest I included gender, the acquisition of a STEM degree and the interaction between the two. The variable that indicates the acquisition of a STEM degree is constructed starting from the variable of the questionnaire that indicates the "classe di laurea" (major). In particular, a major is considered STEM or non-STEM basing on the "Tabella di decodifica della classificazione delle classi di laurea per Field of Education and Training 2013 (ISCED-F 2013) con indicazione delle aree STEM" (Ministero dell'istruzione dell'università e della ricerca [MIUR], n.d.-b).

Finally, I included as control variables indicators of subjects' ability, such as the high school passing grade, the university passing grade and a variable that indicates whether the subject graduated in the normal three- or five-years-time period or not. Other control variables refer to activities undertaken during university that may have an impact on the present occupational situation, like working during university or participating in students' international mobility programmes. Participation in educational or training activities after graduation is also taken into account as a control variable. Finally, I also included indicators of the marital status and the parents' educational level to consider the impact of the family in the analysis.

The dataset that results from the questionnaire contains missing values for some of the variables I considered in the analysis. To solve the problem I dropped the missing observations and the sample went from 58.400 observations to 53.643 observations. The characteristics of the sample remain nonetheless quite similar on average, as shown in the following tables.

Table 4.1 – Characteristics of the initial sample

Variable	Obs	Mean	Std. dev.	Min	Max
Gender	58400	0,55279	0,49721	0	1
STEM	58400	0,28159	0,44978	0	1
Employment status	58400	0,72317	0,44744	0	1
Overall satisfaction	46855	7,17194	1,83868	0	10
Monthly income	44043	1307,13	652,273	10	4000
Months between graduation and first job	52290	8,88183	13,1231	-1	54
Willingness to re-enrol	58400	0,68500	0,46452	0	1

Table 4.2 – Characteristics of the final sample

Variable	Obs	Mean	Std. dev.	Min	Max
Gender	53643	0,55799	0,49663	0	1
STEM	53643	0,28938	0,45348	0	1
Employment status	53643	0,70839	0,45451	0	1
Overall satisfaction	42512	7,15652	1,83257	0	10
Monthly income	42411	1307,67	649,851	10	4000
Months between graduation and first job	48159	8,71671	12,9450	-1	53
Willingness to re-enrol	53643	0,68365	0,46506	0	1

4.2 Methodology

The analysis is structured in two phases. The first one investigates the gender differentials in occupational indicators and their differences in the STEM versus non-STEM fields. Particularly, the focus is on the gender gap in employment, the earnings gender gap, the gender differential in the school-to-work transition time and the gender differential in overall satisfaction. These are studied considering the variation respectively of the employment status, the monthly income, the months between graduation and first job and the overall satisfaction when changing from man to woman and from non-STEM to STEM degree.

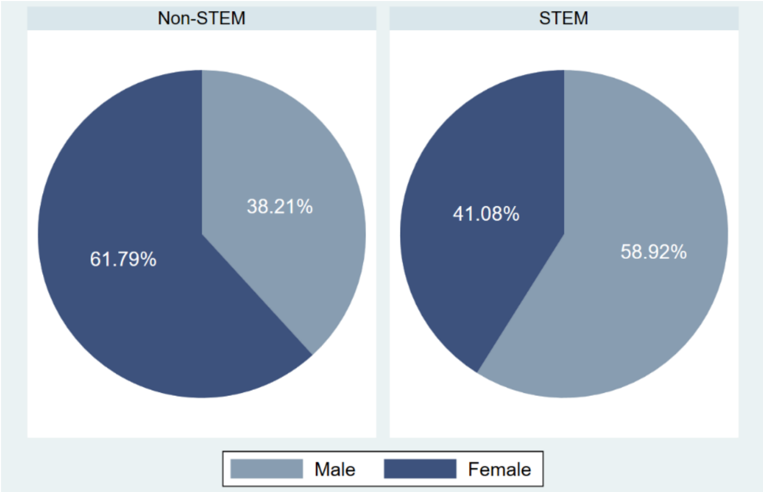
The second phase aims at studying the relationship between the employment situation and the willingness to re-enrol in the same degree program, with a focus on how this influences women in the STEM field. This relationship is interesting because the willingness of graduates to re-enrol in a STEM degree program may be an indicator of the willingness of high school students to choose a STEM degree program. In this stage, the reasons why subjects are unwilling to repeat the same major choice are also investigated. This aspect is indeed crucial to assess the factors that have a major impact on the degree choice and the analysis divides them into three groups: occupation-related factors, university course-related factors and interests-related factors. For this purpose, the analysis examines the impact of gender and STEM field belonging on the probability of being unwilling to repeat the same choice for each of the three reasons separately. In this way, it is possible to understand if the reason changes between men and women and between STEM and non-STEM graduates.

With regard to model specifications, the ones with continuous dependent variables are estimated using a linear regression model. On contrary, in all the cases in which the dependent variable is binary, estimates are performed using a probit model and considering the marginal effects computed at the mean of all the variables. Furthermore, in the case in which the dependent variable is the monthly income, marginal effects are estimated using a log-linear model in order to obtain the semi-elasticity. A set of control variables is included in each specification.

4.3 Descriptive statistics

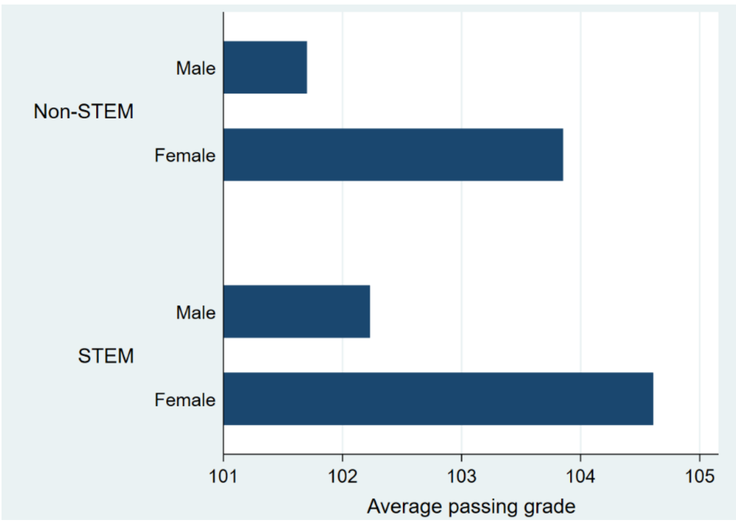
As shown in Figure 4.2, there is an uneven distribution of women and men in STEM and non-STEM fields. As expected, women outnumber men in non-STEM fields, where they are 69.79%, while they constitute only 41.08% of observations in STEM fields.

Figure 4.2 - Share of graduates by gender in STEM and non-STEM fields



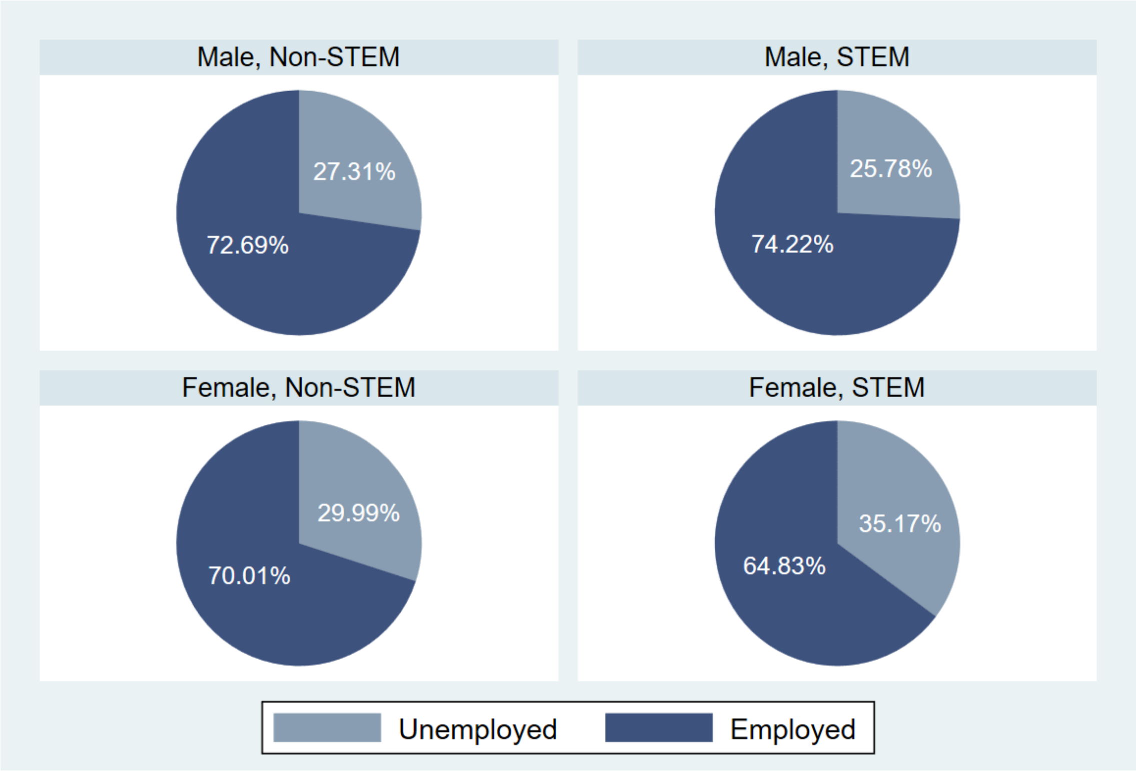
Despite this underrepresentation, women tend to perform better than men in every sector. Moreover, STEM students tend to get higher passing grades than non-STEM ones. Overall, the gender differential in this context is slightly higher in the STEM field, where female students outperform male students by about 2.38 points versus the 2.15 difference points of non-STEM fields, as shown in Figure 4.3.

Figure 4.3 - Average passing grade by gender and field



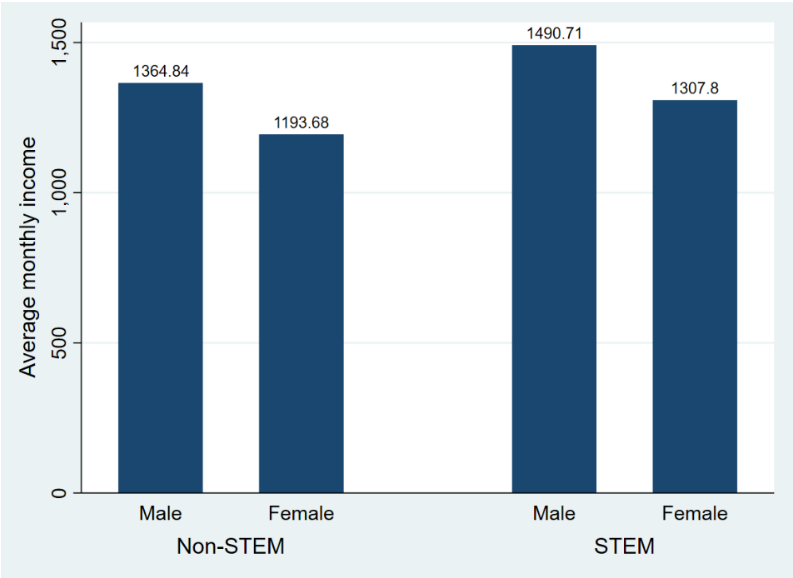
For what concerns the labour market, different indicators are considered in this analysis. The first is the employment status four years after graduation. Figure 4.4 shows that women tend to be less employed than men, regardless of the field. Furthermore, there is a considerable difference in the gender employment gap: in STEM fields it is about 9.39% in favour of men, while in other fields it is about 2,68%.

Figure 4.4 - Employment status four years after graduation by gender and field



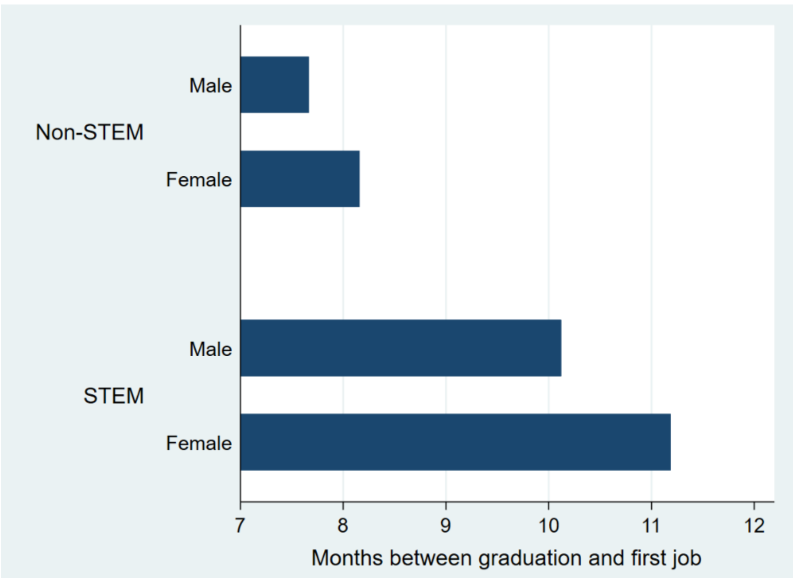
Also regarding income, female graduates earn less than men in every field and those who work in STEM fields tend to have a higher monthly income than others, as displayed in Figure 4.5. In addition, the gender pay gap is higher in STEM fields compared to non-STEM ones.

Figure 4.5 - Average monthly income by gender and field



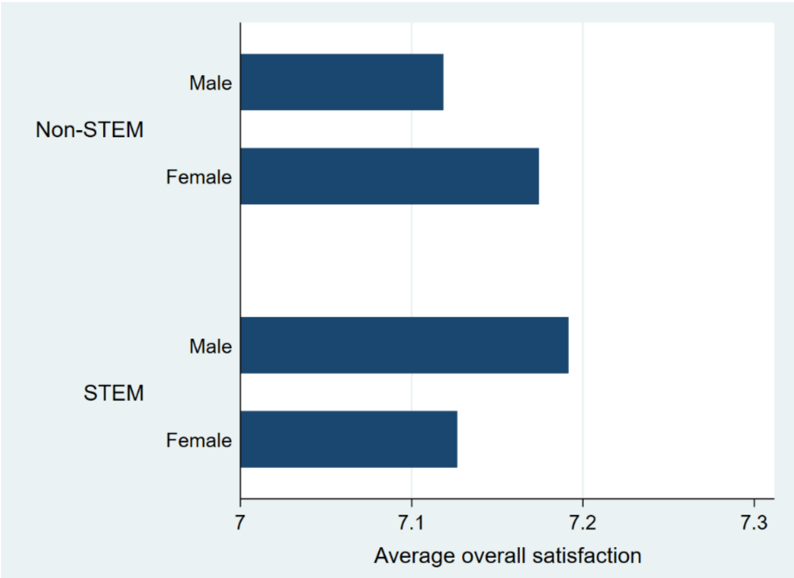
Looking at school-to-work transition, Figure 4.6 demonstrates the average months that elapse between graduation and the start of the first job. Unexpectedly, there is a substantial difference in favour of non-STEM graduates, who are able to find their first job in about 8 months on average, compared to the about 10.5 months of STEM graduates. For what concerns the gender gap in this context, it is possible to observe that the gap in STEM (1.06 months) is larger than the gap in other fields (0.49 months).

Figure 4.6 - Average months between graduation and first job



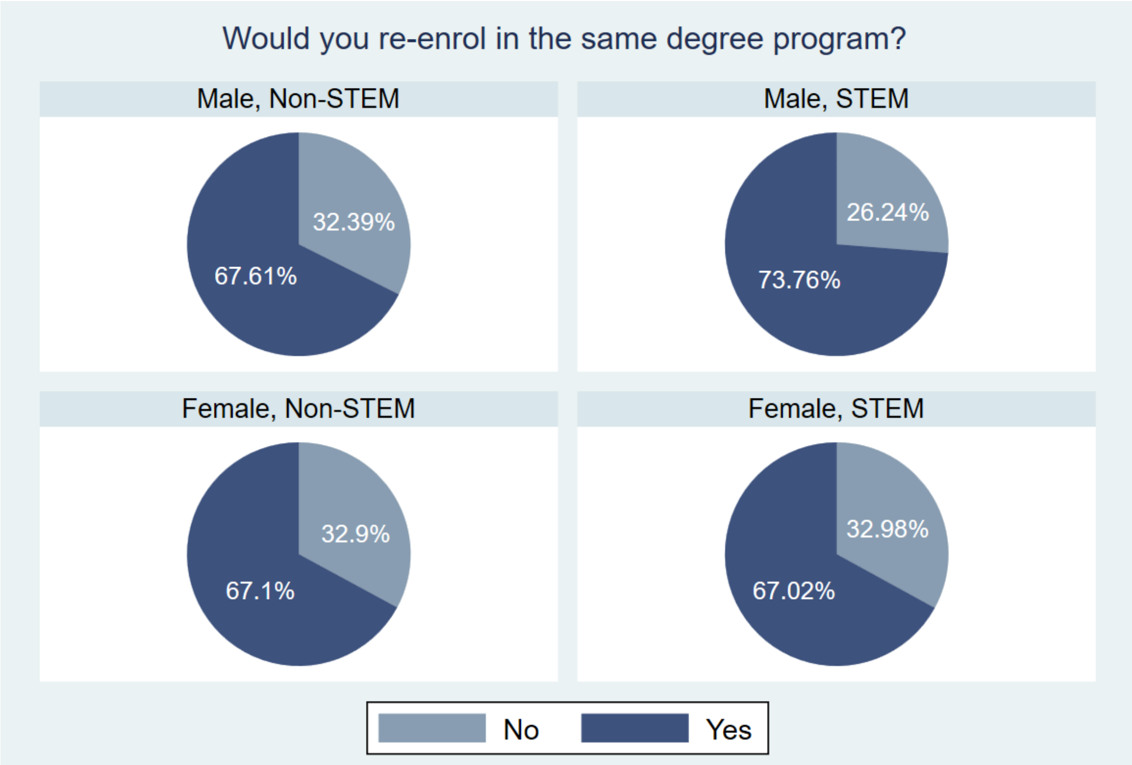
As reported before, the perception of the working environment and the relationships that are related to this area play a crucial role in the context of major decisions. For this reason, the overall satisfaction with the work experience is an important factor to consider in the analysis. In this dataset, the averages of overall satisfaction are quite similar between genders and fields of study, as appears in Figure 4.7. An interesting thing to note is that while in STEM fields the gender differential is in favour of men, in non-STEM fields it is in favour of women. This is in line with the expectations of the role congruity theory mentioned in the previous Section.

Figure 4.7 - Average overall satisfaction for the working experience by gender and field



Lastly, for the aim of this analysis is essential to examine the distribution of graduates who states that they would re-enrol in the same degree program and those who do not. As displayed in Figure 4.8, in non-STEM fields the gender differential is minimal and about 67% of the subjects state that they would re-enrol. The share is similar also among STEM female graduates, but in STEM fields the gender differential is much higher, with about 74% of STEM male graduates who say that they would repeat their choice.

Figure 4.8 - Willingness to re-enrol in the same degree course by gender and field



4.4 *Econometric results*

4.4.1 *Gender differential in working conditions: STEM vs non-STEM*

The first stage of this analysis aims at identifying potential gender differences in working conditions and comparing those in the STEM fields with those in other fields. For this purpose, the analysis focuses on how gender and field of study impact four labour-related variables. While the first three variables (employment status, monthly income, and months between graduation and first job) are objective, the fourth variable (overall satisfaction) is linked to subjective evaluation, expectations and perception of the working environment.

Table 4.3 displays a summary of the main econometric result for what concern the variables of interest; the complete estimates can be found in Table A1 in the Appendix.

Table 4.3 - Main econometric results on working conditions

VARIABLES	Employment status	(Log of) Monthly income	Months between graduation and first job	Overall satisfaction
gender_stem	-0.0542***	-0.0199	0.270	-0.0800*
	(0.00949)	(0.0156)	(0.274)	(0.0424)
gender	-0.0238***	-0.145***	0.0930	0.00769
	(0.00496)	(0.00911)	(0.141)	(0.0241)
stem	0.0579***	0.205***	0.855***	0.0195
	(0.00604)	(0.0110)	(0.188)	(0.0290)
Observations	53,643	38,000	38,000	38,000
R-squared		0.095	0.214	0.016
Pseudo R-squared	0.1072			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Firstly, looking at the employment status it is possible to note that the coefficient of gender, stem and their interaction are all statistically significant. In particular the coefficient of stem signals that STEM graduates are 5.79% more likely to be employed four years after graduation than non-STEM graduates. Regarding gender differentials, the coefficient of the interaction term is negative, meaning that the gender gap is wider in STEM fields than in other fields. While non-STEM female graduates have 2.38% less probability of being employed compared to men in the same fields, STEM female graduates are indeed 7.80% less likely to be employed than their male colleagues.

Secondly, estimates indicate that the difference in gender pay gaps between STEM and non-STEM fields is negligible since the coefficient of the interaction term is negative but statistically insignificant. Nevertheless, data show substantial gender and field earning gaps. For what concerns gender pay gap, data display that women earn 14.5% less than men, regardless of the field of study. This corresponds to an earning differential of about 201.55€. As regards the field of study, STEM graduates earn 20.5% more than non-STEM graduates, which is the equivalent of a 187.24€ pay gap.

Thirdly, coefficients of gender and gender_stem in the regression about school-to-work transition time (in months) are both positive, indicating a gender differential in favour of men higher in STEM fields, but not statistically significant. Therefore, there is no clear evidence of gender differential in all the fields. There is, however, a gender gap in school-to-work transition time when comparing STEM to non-STEM graduates. In particular, finding the first job for STEM graduates take 0.855 months (about 26 days) longer than for other graduates.

Finally, evidence about gender and field differentials in overall satisfaction with the working environment is more ambiguous. Neither the coefficient of stem nor that of gender are statistically significant and both are positive but small, indicating negligible gender and field gaps in satisfaction. The coefficient of the interaction term is -0.08, indicating a difference between the gender gaps in satisfaction in STEM versus non-STEM fields in favour of non-STEM ones, but it is statistically significant only at a 10% confidence level. To sum up, the results about this variable are not clear and this may arise from the fact that satisfaction is a subjective variable and pertains to the perception graduates have of their job.

For what concern control variables, it is possible to note that regional effects are significant only in income and school-to-work transition regressions. The high school passing grade, which can be considered as a proxy for the ability at the beginning of university, is statistically significant in all the regressions. As expected, having a higher high school passing grade increases income, but it also extends the school-to-work transition time. This may arise from the fact that individuals with higher ability may decide to continue studying for a longer time or they may be pickier when looking for a job. Participation in international mobility programmes has also an important impact, making income raise by about 15,9% and decreasing the school-to-work transition time by about one month. Working during university has also a positive impact on labour market variables, especially in the case of continuous jobs, which increase the probability of being employed by 24.9%, increase the income by 19.4% and decrease by about 11 months the time between graduation and first job. Graduating in the expected time has also a positive impact on these variables, while the passing grade has statistically significant, but very small effects on income, school-to-work transition time and satisfaction. The enrolment in other university courses or training activities outside university as expected delays the start of the first job and, therefore, decreases the probability of being employed and the monthly income and increases the time between graduation and the first job. Finally, the effects of parents' educational level are not statistically significant.

4.4.2 Gender differences in the choice of re-enrolment

The second stage of this analysis aims at examining the relationship between the gender and field differentials in working conditions and the differential in the willingness to re-enrol in the same degree program. As previously mentioned, the willingness to re-enrol may be considered as an index of the willingness of high-school students to enrol in that program and, therefore, it is a useful variable to consider when analysing the major choice process. In this phase, I first analyse the gender and field differentials in the willingness to re-enrol and then I examine the gender and field differentials in the reasons why graduates state that they would not repeat their initial major choice.
Table 4.4 displays a summary of the main econometric result for what concern interest variables, the complete outcomes can be found in Table A2 in the Appendix.

Table 4.4 - Summary of main econometric results of the second phase

VARIABLES	Willingness to re-enrol	Reason 1: work	Reason 2: course	Reason 3: interests
gender_stem	-0.0586***	0.0674***	-0.0257*	-0.0391**
	(0.0107)	(0.0205)	(0.0154)	(0.0153)
gender	-0.00429	0.0219*	-0.00919	-0.00379
	(0.00553)	(0.0116)	(0.00924)	(0.00935)
stem	0.0405***	-0.0537***	0.0377***	0.0226*
	(0.00681)	(0.0151)	(0.0121)	(0.0121)
Observations	42,326	12,007	12,002	12,002
Pseudo R-squared	0.0442	0.0489	0.0174	0.0394

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

First of all, it is possible to observe a statistically significant difference in the gender gap in willingness to re-enrol between STEM and non-STEM. Specifically, the gender gap in willingness to re-enrol is practically absent in non-STEM fields (the coefficient of gender is negative but statistically insignificant), whereas the gender gap emerges in STEM fields, where women are 5.86% less likely than men to say that they would re-enrol in the same degree program. In addition, the coefficient of stem is positive and statistically significant, indicating that in general STEM graduates are 4.05% more likely than other graduates to affirm that they would repeat the same major choice.

For what concern control variables in this regression, it is possible to note that those with higher high school passing grades are more willing to re-enrol. Experiences during university also seem to have an impact on this choice, since participating in international mobility programmes and working during university decreases the probability that graduates say that they would re-enrol. Predictably, graduating in the course's expected time and getting a higher passing grade increases the willingness to re-enrol and the same applies to enrolling in other university courses after graduation. Regarding working conditions, being employed unexpectedly decreases the willingness to repeat the same major choice and the income has only a minimal positive impact on this decision. Finally, unmarried graduates are less likely than married ones to say that they would re-enrol in the same degree program.

With regards to the reasons why graduates affirm that they would not repeat their major choice, results show the importance of career opportunities in explaining the gender gap in the unwillingness to re-enrol in STEM courses. It is indeed possible to observe that, although evidence of the gender gap in non-STEM fields is statistically significant only at a 10% confidence level, the coefficient of the interaction term is bigger and it is also statistically significant at a 1% confidence level. This means that even if the gender gap in non-STEM fields is negligible, female STEM graduates are 6.74% more likely than their male colleagues to say that the reason why they would not re-enrol in the same degree program is the dissatisfaction with working opportunities. Furthermore, also in this case, it is possible to observe a general field differential in favour of STEM graduates, who are 5.37% less willing to be unsatisfied with their working opportunities than other graduates.

For what concern university-related aspects, like the dissatisfaction with courses' content, organization and level of effort required, the results about gender differential are mixed and statistically insignificant. There is, however, a field differential: STEM graduates are

3.77% more likely than non-STEM graduates to be unsatisfied with the aspects related to the university course mentioned above.

Lastly, the coefficient of the gender gap in non-STEM fields is statistically insignificant, while the coefficient of the gender gap in STEM fields is negative and significant at a 5% confidence level, resulting in evidence of the fact that female STEM graduates are 3.91% less likely than their male colleagues to say that they would not repeat the same major choice because their interests changed over time.

Regarding control variables, also for these regression high school passing grades is relevant, because it decreases the probability of being unsatisfied with employment opportunities, while it increases the probability of being unsatisfied with the university course and the probability of changing interests. Also, the participation in international mobility programmes and the enrolment in other university courses after graduation have the same effects on these variables. These results may be due to the fact that prior ability (measured by the high school passing grade) and experiences like international mobility and additional courses enhance occupational opportunities regardless of the chosen major, leading to lower dissatisfaction levels. The university passing grade, the monthly income and the school-to-work transition time have, instead, a statistically significant but very small effect only on the reasons of job opportunities and interests.

To summarize, previous estimates highlight the existence of a gender gap in employment status between female and male graduates, which is even larger in the STEM field. Results about differences between STEM and non-STEM fields in gender earning gap, school-to-work transition time gap and satisfaction gap are instead mixed. Further estimates show that female and male non-STEM graduates are equally willing to re-enrol in the same degree programs, while in STEM fields female graduates are less likely than their male colleagues to say that they would repeat the same choice. Moreover, it shows that the gender differential in dissatisfaction with employment perspectives in STEM is higher than in other fields.

4.5 Policy implications

The results of the analysis indicate that the working conditions of women are worse than those of their male colleagues, especially in STEM. Moreover, they show that women in STEM are less willing to re-enrol in the same degree course and the main reason is related to labour market opportunities. These outcomes are in line with the literature discussed in the previous Section and lead to some possible policy advice to overcome the issue of the under-representation of women in STEM fields.

Firstly, on the demand side of the STEM labour market, it is necessary to eliminate the prejudices and the discrimination in the hiring process of STEM firms. This objective may be pursued through, for example, the implementation of a more transparent and meritocratic interviewing process and through the presence of other women in the hiring team.

Employment status, however, is not the only critical point that affects women's satisfaction with their degree courses. The context of employment opportunities also includes compensation, career advancement possibilities, the working environment and the relationship with colleagues and supervisors. For what concerns wages, the starting point is the legal prohibition of gender pay discrimination. Beyond that, other actions that may be implemented are work-life support policies, which can help women with childcare and family obligations, and the use of more objective factors (like the value of the work) as tools to determine wages. Finally, reporting systems and complaint procedures should be implemented in order to allow women to discuss their wages and the pay gap with their male colleagues without the risk of employer retaliation.

As regards career advancement possibilities, besides a more transparent promotion system that prevents discrimination, it is essential to implement, both within and outside firms, policies that help women to reach a satisfying work-life balance. This does not only prevent experienced female workers to drop out the STEM career, forcing firms to promote only men in the higher positions, but it allows also women who choose to have a family while working to do so, preventing them from putting their career on pause during pregnancy and motherhood.

For what concerns the working environment and the relationship with colleagues and supervisors, the main issues, especially in male-dominated fields like STEM, are the supervisors' differences in treatment between women and men employees and the "boys club" atmosphere, which can make women feel isolated. Policies aimed at removing these issue may be mobbing, discrimination and also harassment reporting systems that protect women and that discourages men to act in such ways.

All the policies reported before do not only have an impact on the demand side of the labour market. Creating a more welcoming working environment for women and allowing them to have the same possibilities as men encourage women to decide to pursue a career in STEM, leading to an increase in women's labour supply in these fields.

In this way, it is thus possible to activate a virtuous circle: if more women decide to pursue a STEM career and are not discriminated in this process, they will be able to climb the corporate ladder and promote female-friendly policies, making the STEM fields more appealing to girls who are deciding their major at university and leading in this way to an increase in the number of women choosing the STEM career path. Furthermore, during this process the gender composition of these fields would change, making them always less male-dominated, and this may be the starting point of the eradication of the stereotypes identified by the gender role congruity theory.

Evidence shows nonetheless that employment possibilities are not the only determinants of high school students' major choices. For this reason, policies aimed at increasing women's participation in the STEM labour market need to be activated also in education. Just like in the labour market, the main issues to overcome in education are discrimination and, above all, stereotypes. For what concerns discrimination, it is crucial that both high school teachers and university faculties treat their students in the same way, avoiding conscious and unconscious biases. With this view, policies aimed at informing teachers of the possible unconscious predisposition to favour boys in scientific subjects may be helpful. Looking at the misconception about the fact that girls do not belong to STEM fields, it may be mitigated by the presence of female role models. As a consequence, policies like events that promote women in science and high schools' science contests may persuade girls to choose a STEM major at university. Moreover, parents' and teachers' beliefs about women in science are key determinants of those of high school students. For this reason, actions aimed at raising awareness about these topics in general, like the institution of international women in STEM days and the presence of female science popularisers, may help with this goal.

To conclude, there are several actions that can be taken to start a process of change in this context and they are all essential to reach the goal of increasing women's participation in STEM education and the labour market.

Appendix

Table A1 – Complete estimates of the first phase regressions

VARIABLES	Employment status	Log income	Months	Satisfaction
gender_stem	-0.0542***	-0.0199	0.270	-0.0800*
	(0.00949)	(0.0156)	(0.274)	(0.0424)
gender	-0.0238***	-0.145***	0.0930	0.00769
	(0.00496)	(0.00911)	(0.141)	(0.0241)
stem	0.0579***	0.205***	0.855***	0.0195
	(0.00604)	(0.0110)	(0.188)	(0.0290)
reg1	0.0686	-0.187***	0.749	0.0938
	(0.0487)	(0.0604)	(0.784)	(0.228)
o.reg2		-	-	-
reg3	0.0762	-0.129**	1.179	0.0666
	(0.0499)	(0.0591)	(0.762)	(0.226)
reg4	0.0276	-0.113*	2.518***	0.326
	(0.0545)	(0.0626)	(0.873)	(0.233)
reg5	0.0637	-0.208***	1.641**	0.0474
	(0.0495)	(0.0598)	(0.776)	(0.227)
reg6	0.0117	-0.156**	1.979**	0.0957
	(0.0555)	(0.0609)	(0.811)	(0.230)
reg7	0.0408	-0.263***	2.860***	0.117
	(0.0525)	(0.0632)	(0.841)	(0.232)
reg8	0.0272	-0.204***	2.079***	0.0241
	(0.0535)	(0.0596)	(0.775)	(0.227)
reg9	0.0118	-0.251***	1.644**	0.0348
	(0.0550)	(0.0603)	(0.783)	(0.228)
reg10	-0.0147	-0.301***	2.710***	-0.143
	(0.0587)	(0.0638)	(0.862)	(0.235)
reg11	0.0125	-0.368***	2.822***	-0.0512
	(0.0552)	(0.0618)	(0.810)	(0.230)
reg12	-0.0144	-0.260***	1.749**	-0.174
	(0.0571)	(0.0595)	(0.769)	(0.227)
reg13	-0.0229	-0.334***	2.129***	0.0119
	(0.0588)	(0.0620)	(0.814)	(0.232)
reg14	-0.0553	-0.431***	3.536***	-0.106
	(0.0659)	(0.0784)	(1.079)	(0.262)
reg15	-0.0765	-0.363***	2.865***	-0.269
	(0.0618)	(0.0604)	(0.788)	(0.228)

reg16	-0.0909	-0.374***	3.222***	-0.0836
	(0.0636)	(0.0623)	(0.825)	(0.232)
reg17	-0.0476	-0.341***	4.176***	0.260
	(0.0660)	(0.0775)	(1.229)	(0.275)
reg18	-0.141**	-0.515***	3.639***	-0.141
	(0.0667)	(0.0652)	(0.876)	(0.237)
reg19	-0.101	-0.393***	4.022***	-0.152
	(0.0635)	(0.0611)	(0.802)	(0.230)
reg20	-0.0696	-0.367***	3.052***	-0.115
	(0.0629)	(0.0639)	(0.844)	(0.235)
citizenship	0.0408**	-0.0201	0.343	0.242**
	(0.0192)	(0.0324)	(0.497)	(0.0971)
hs_grade1		-0.0756***	-1.065***	-0.139***
		(0.0105)	(0.169)	(0.0278)
hs_grade2	-0.00979**	-0.0492***	-0.419***	-0.102***
	(0.00491)	(0.00917)	(0.154)	(0.0237)
o.hs_grade3		-	-	-
int_mobility	0.0141**	0.159***	-1.016***	0.0111
	(0.00675)	(0.0122)	(0.194)	(0.0317)
uni_work1	0.110***	-0.0487***	-5.013***	-0.198***
	(0.00412)	(0.00864)	(0.151)	(0.0219)
uni_work2	0.249***	0.194***	-11.19***	-0.0504*
	(0.00393)	(0.0101)	(0.152)	(0.0278)
o.uni_work3		-	-	-
in_time	0.0793***	0.153***	-0.444***	0.277***
	(0.00436)	(0.00789)	(0.127)	(0.0210)
passing_grade	0.000275	0.00181***	-0.0856***	-0.00397***
	(0.000291)	(0.000528)	(0.00824)	(0.00141)
other_courses	-0.122***	-0.112***	6.540***	-0.00281
	(0.00419)	(0.00782)	(0.138)	(0.0205)
training_activities	-0.110***	-0.0864***	0.750***	-0.0734***
	(0.00396)	(0.00726)	(0.120)	(0.0197)
marital_status1	-0.0229	-0.106***	2.016***	-0.214***
	(0.0228)	(0.00968)	(0.134)	(0.0265)
o.marital_status2		-	-	-
marital_status3		0.0644**	0.0101	-0.198*
		(0.0320)	(0.345)	(0.108)
educ_f1	0.0121	0.0388	-0.461	-0.0572
	(0.0158)	(0.0317)	(0.477)	(0.0792)
educ_f2	0.00757	0.0212	-0.250	-0.0841

	(0.0147)	(0.0300)	(0.453)	(0.0729)
educ_f3	0.0196	0.0209	-0.113	-0.0583
	(0.0143)	(0.0295)	(0.443)	(0.0713)
o.educ_f4		-	-	-
educ_f5	-0.0160	-0.00294	-0.162	-0.0847
	(0.0151)	(0.0305)	(0.458)	(0.0737)
educ_f6	-0.0247	-0.0233	-0.313	0.0476
	(0.0255)	(0.0468)	(0.728)	(0.121)
educ_m1	0.0160	0.0458*	-0.642	0.0160
	(0.0131)	(0.0251)	(0.394)	(0.0646)
educ_m2	0.0338***	0.0151	-0.201	0.0159
	(0.0115)	(0.0230)	(0.366)	(0.0570)
educ_m3	0.0318***	0.0189	-0.176	0.0412
	(0.0113)	(0.0224)	(0.354)	(0.0546)
o.educ_m4		-	-	-
educ_m5	0.0123	0.0231	0.444	0.0405
	(0.0119)	(0.0240)	(0.381)	(0.0586)
educ_m6	-0.00827	-0.0562	-0.0171	-0.237*
	(0.0251)	(0.0457)	(0.750)	(0.127)
hs_grade3	-0.0329***			
	(0.00595)			
marital_status2	-0.00536			
	(0.0239)			
Constant		7.153***	15.57***	7.616***
		(0.0926)	(1.322)	(0.297)
Observations	53,643	38,000	38,000	38,000
R-squared		0.095	0.214	0.016
Pseudo R-squared	0.1072			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2 - Complete estimates of the second phase regressions

VARIABLES	Willingness to re-enrol	Reason 1: work	Reason 2: course	Reason 3: interests
gender_stem	-0.0586***	0.0674***	-0.0257*	-0.0391**
	(0.0107)	(0.0205)	(0.0154)	(0.0153)
gender	-0.00429	0.0219*	-0.00919	-0.00379
	(0.00553)	(0.0116)	(0.00924)	(0.00935)
stem	0.0405***	-0.0537***	0.0377***	0.0226*
	(0.00681)	(0.0151)	(0.0121)	(0.0121)
reg1	-0.00184	-0.101	0.0111	-0.0421
	(0.0333)	(0.0706)	(0.0509)	(0.0396)
reg2	0.191***	0.123		
	(0.0397)	(0.227)		
reg3	0.0106	-0.123*	0.0419	-0.0546
	(0.0319)	(0.0686)	(0.0512)	(0.0387)
reg4	0.0119	-0.165**	0.0128	-0.00894
	(0.0348)	(0.0733)	(0.0556)	(0.0478)
reg5	0.00438	-0.141**	0.0645	-0.0491
	(0.0326)	(0.0690)	(0.0555)	(0.0384)
reg6	0.0187	-0.0859	0.0646	-0.0915***
	(0.0329)	(0.0728)	(0.0590)	(0.0332)
reg7	-0.00797	-0.136*	0.114*	-0.0920***
	(0.0353)	(0.0727)	(0.0648)	(0.0336)
reg8	0.0158	-0.0913	0.0305	-0.0708**
	(0.0319)	(0.0697)	(0.0519)	(0.0357)
reg9	0.0280	-0.109	0.0708	-0.0913***
	(0.0315)	(0.0703)	(0.0573)	(0.0326)
reg10	-0.0356	-0.0749	0.0936	-0.114***
	(0.0372)	(0.0746)	(0.0638)	(0.0298)
reg11	0.0342	-0.0935	0.00650	-0.0548
	(0.0317)	(0.0723)	(0.0518)	(0.0390)
reg12	-0.00197	-0.0525	0.00702	-0.0856**
	(0.0326)	(0.0695)	(0.0490)	(0.0342)
reg13	0.0386	-0.0878	0.0308	-0.0807**
	(0.0318)	(0.0735)	(0.0562)	(0.0355)
reg14	-0.00502	-0.175**		
	(0.0425)	(0.0853)		
reg15	0.000511	0.0221	-0.00782	-0.121***
	(0.0329)	(0.0692)	(0.0480)	(0.0282)
reg16	0.00201	-0.0387	0.0374	-0.114***
	(0.0339)	(0.0727)	(0.0560)	(0.0293)

reg18	-0.0175	0.0535	-0.0304	-0.121***
	(0.0361)	(0.0723)	(0.0484)	(0.0284)
reg19	-0.0190	-0.0521	0.0445	-0.108***
	(0.0341)	(0.0708)	(0.0547)	(0.0300)
reg20	-0.0182	-0.111	0.0383	-0.0645*
	(0.0358)	(0.0732)	(0.0574)	(0.0385)
citizenship	-0.0286	-0.0387	0.0373	-0.0137
	(0.0191)	(0.0434)	(0.0306)	(0.0354)
hs_grade1	-0.0165**			
	(0.00662)			
hs_grade2	-0.0239***	-0.0530***	0.0235***	0.0263***
	(0.00573)	(0.0111)	(0.00888)	(0.00899)
int_mobility	-0.0527***	-0.0786***	0.0311**	0.0313**
	(0.00796)	(0.0153)	(0.0123)	(0.0126)
uni_work1	-0.0771***	-0.0132	0.000306	-0.0235**
	(0.00530)	(0.0113)	(0.0100)	(0.0100)
uni_work2	-0.0565***	-0.0373**		
	(0.00739)	(0.0150)		
in_time	0.0840***	0.00976	-0.0186**	0.0119
	(0.00487)	(0.0101)	(0.00791)	(0.00811)
passing_grade	0.00205***	0.00549***	-0.000834	-0.00428***
	(0.000321)	(0.000663)	(0.000521)	(0.000520)
occup_status	-0.0802***	0.0451**	-0.0425***	-0.0152
	(0.00702)	(0.0185)	(0.0156)	(0.0153)
other_courses	0.0240***	-0.0514***	0.00263	0.0529***
	(0.00485)	(0.0103)	(0.00800)	(0.00845)
training_activities	-0.00782	-0.00249	-0.00570	-0.00183
	(0.00480)	(0.0100)	(0.00792)	(0.00801)
marital_status1	-0.0487***	-0.0275**	-0.0162	-0.0418
	(0.00601)	(0.0136)	(0.0448)	(0.0461)
marital_status3	0.0324	-0.0999*		
	(0.0223)	(0.0564)		
educ_f1	0.00909	-0.0438	0.00523	0.0229
	(0.0245)	(0.0515)	(0.0411)	(0.0428)
educ_f2	-0.00781	-0.0333	0.00364	0.0144
	(0.0241)	(0.0492)	(0.0390)	(0.0398)
educ_f3	0.000852	-0.0646	0.0282	0.0227
	(0.0237)	(0.0487)	(0.0392)	(0.0392)
educ_f4	0.0294	-0.0750	0.0155	0.0600
	(0.0270)	(0.0601)	(0.0492)	(0.0542)
educ_f5	-0.00210	-0.107**	0.0452	0.0471
	(0.0243)	(0.0498)	(0.0426)	(0.0427)
educ_m1	0.0485***	0.103*	-0.0360	0.000798

	(0.0141)	(0.0546)	(0.0223)	(0.0255)
educ_m2	0.0257*	0.0873	-0.0320	0.0163
	(0.0133)	(0.0545)	(0.0205)	(0.0229)
educ_m3	0.00938	0.0831	-0.0237	0.0136
	(0.0131)	(0.0551)	(0.0204)	(0.0216)
educ_m5	0.00338	0.0766	-0.0303	0.0207
	(0.0139)	(0.0550)	(0.0205)	(0.0238)
educ_m6	0.0389		0.0116	0.0755
	(0.0268)		(0.0481)	(0.0551)
income	9.58e-05***	-0.000131***	3.38e-05***	7.40e-05***
	(3.98e-06)	(8.24e-06)	(6.01e-06)	(6.05e-06)
stw_months	-0.000286	0.00140***	-0.000422	-0.000908***
	(0.000191)	(0.000393)	(0.000308)	(0.000320)
hs_grade3		-0.0904***	0.0341***	0.0523***
		(0.0140)	(0.0116)	(0.0120)
educ_m4		0.0422		
		(0.0596)		
reg17			-0.0657	-0.0856*
			(0.0599)	(0.0488)
uni_work3			-0.0193*	-0.0120
			(0.0114)	(0.0116)
marital_status2			-0.0331	-0.0504
			(0.0406)	(0.0385)
Observations	42,326	12,007	12,002	12,002
Pseudo R-squared	0.0442	0.0489	0.0174	0.0394

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 *Conclusion*

The aim of this dissertation was to investigate the relationship between the situation in the labour market and the university degree choice, in an effort to understand and explain the underrepresentation of women in STEM.
For this purpose, I first presented the different definitions of STEM and the reasons for the necessity of a unique definition of STEM fields both for research purposes, as expressed by Manly et al. (2018), and for policy decisions, as expressed by Donahoe (2013). Then, I illustrated the situation in education and in the labour market using statistics from organizations at international, European and Italian levels. For what concerns education, statistics show that, despite the decrease in the gender segregation in STEM over the past decades, women are still a minority of STEM students and graduates, especially in certain sub-fields (like ICT), and this is particularly true for Italy. Regarding the labour market, the situation is similar, with women that are underrepresented in the majority of the sub-fields and also in academia. In this context, I discussed also the problem of the high drop-out rate of women in STEM fields. Furthermore, after illustrating some of the more relevant policies which have been implemented in the past years, I highlighted the presence of possible unintended effects of these policies (like a decrease in women's sense of belonging in these fields) and possible solutions.

With the purpose of understanding the dynamics underlying the underrepresentation of women in STEM and finding a suitable empirical strategy for the analysis, I critically reviewed the existing literature on the topic. Firstly, I examined the link between labour market and STEM degree choice, noticing the presence of both gender stereotypes that create a lack of supply of women labour force in STEM, and barriers that women have to face in the working environment that create issues on the demand side. Among the latter, the gender pay gap is particularly relevant, since, as found by Beffy et al. (2012) and Berger (1988), expected earnings are important determinants of schooling choices. More recent studies highlight also the fact that students are often not well informed about the labour market outcomes in different fields and that they tend to change their major preferences (often in favour of STEM) once information is provided (Baker et al., 2018); nonetheless, Ding et al. (2021) show that female students tend to be less responsive to

monetary incentives also after receiving information. In any case, VanHeuvelen & Quadlin (2021), Xu (2015) and Michelmore & Sassler (2016) show that earning differences between women and men are especially pronounced in STEM occupations.
Secondly, I reported the glass ceiling and the glass cliff effects in STEM. The first refers to the barriers that women face due to their gender when they try to climb the corporate hierarchy. Moss-Racusin et al. (2012) find that this process starts already at early stages of the career and several studies highlight how it persists during all the professional life phases, even if it takes different forms like lack of mentorship, unsupportive working environment and lack of authority in leadership positions. The glass cliff effect refers instead to the tendency for women to be more likely than men to be appointed to leadership positions that are risky and precarious, both because women tend to be promoted to leadership positions in times of crises and because when they reach leadership positions, they are not supported by their colleagues (Ryan et al., 2016; Wilson-Kovacs et al., 2006). Thirdly, I presented the Matilda effect, which consists in the fact that women are systematically under-recognised for their contributions to research in favour of their male colleagues. This effect expresses itself through the disparity in the perception of male- and female-authored contributions in favour of men (Knobloch-Westerwick et al., 2013), the under-recognition of the contribution of women in teams (Heilman & Haynes, 2005), and the disparity in the proportion of awards won by women compared to men in STEM fields (Lincoln et al., 2012).
I also investigated factors that are unrelated to the labour market, but influence the major choice primarily through their impact on self-efficacy and readiness to study STEM at university. I examined peer effects, but studies show mixed results about how the share of female classmates impacts the willingness to enrol in a STEM degree at university (Brenøe & Zölitz, 2020; Park et al., 2018), and the topic is also complicated by the possible presence of heterogeneous effects linked to preferences for different subjects (Pregaldini et al., 2020). The role of teachers is also relevant for the major choice because teachers are role models for their students and they can shape their behaviours and beliefs. For what concerns secondary school, studies show that the choice of pursuing a STEM degree is influenced by the teachers' gender, behaviours and attitudes (Bottia et al., 2015; Sansone, 2017; Stearns et al., 2016). Regarding university, scholars have mixed opinions

about the impact of faculty gender on female and male academic performance (Bettinger & Long, 2005; Canes & Rosen, 1995; Solanki & Xu, 2018).

In the last main Chapter, I presented the empirical analysis conducted on the dataset coming from the survey "Inserimento professionale dei laureati" ("Labour market conditions of University graduates") 2015 edition, by the Istituto Nazionale di Statistica (ISTAT). The survey, aimed at analysing the school-to-work transition of university graduates, was conducted in 2015 and refers to the 2011 graduates cohort. The sample was selected using an incomplete stratified sampling design and the survey was conducted with a mixed technique Cawi/Cati. The questionnaire covered three main topics, study curriculum, employment history and household information, and in the analysis, I considered variables from all these categories. After dropping observations with missing values for the variables of interest, the final sample was made of 53.643 observations. Before conducting the econometric analysis, I reported some descriptive statistics regarding the variables of interest, comparing STEM and non-STEM graduates and female and male graduates.

The econometric analysis was structured in two phases. The first one investigates the gender differentials in labour market indicators and their differences in the STEM versus non-STEM fields. Particularly, the focus is on the gender gap in employment, the earnings gender gap, the gender differential in the school-to-work transition time and the gender differential in overall satisfaction. The second phase aims at studying the relationship between the employment situation and the willingness to re-enrol in the same degree program, with a focus on how this influences women in the STEM field. This relationship is interesting because the willingness of graduates to re-enrol in a STEM degree program may be an indicator of the willingness of high school students to choose a STEM degree program. The reasons why subjects are unwilling to repeat the same major choice are also investigated.

The analysis was conducted using linear regression models, log-linear models and probit models, depending on the nature of the dependent variable and a set of control variables was included in each specification.

The econometric results highlighted the existence of a gender gap in employment status between female and male graduates, which is even larger in the STEM field. Results about differences between STEM and non-STEM fields in gender earning gap, school-to-work transition time gap and satisfaction gap were instead mixed. Further estimates showed that female and male non-STEM graduates are equally willing to re-enrol in the same degree programs, while in STEM fields female graduates are less likely than their male colleagues to say that they would repeat the same choice. Moreover, results showed that the gender differential in dissatisfaction with employment perspectives in STEM is higher than in other fields.

To conclude, the results of the analysis, together with the existing literature, suggest some possible policy advice to overcome the issue of the underrepresentation of women in STEM. Actions to eliminate stereotypes and discrimination are required regarding several aspects of the STEM education and working environment, like the hiring process, wages and the relationships with colleagues. Creating a more welcoming environment for women and allowing them to have the same possibilities as men encourage women to decide to pursue the STEM career, leading to a more balanced environment from which both women and men can benefit.

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