Girls' career aspirations in STEM

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Executive Summary

This study investigates the determinants and drivers of girls' career aspirations in science, technology engineering and mathematics (STEM). It is based on a literature review and an in-depth descriptive and econometric analysis of OECD PISA 2018 microdata. The motivation for this study is the persistent under-representation of women in the labour market for science and technology. Increasing the proportion of women in STEM is important to expanding the labour force in science and technology (ICT), increasing women's access to well-paid jobs, and promoting the development of technology that is not gender biased. As Commissioner Mariya Gabriel said in her speech at an ICT/STEM event, The work for the future or how to attract young people for careers in ICT and STEM?, "O*nly one in three STEM graduates is a woman. On average, women make up only 17% of tech-sector jobs*."[1]

Career aspirations during adolescence have been shown to be good predictors of actual career choices in adulthood though career preferences can be formed earlier. Hence, by providing insights on the drivers of girls' aspirations when they may be making choices about upper secondary and tertiary education, this study helps understand the reasons for lower participation of women in the STEM sector and what policy initiatives can drive up girl's aspirations in STEM and ICT occupations.

Conceptual framework for the study

The conceptual framework of this study is based on the Social-Cognitive Career Theory (SCCT), which hypothesises that the main drivers of career aspirations in STEM are:

- **STEM self-efficacy beliefs**: individual self-awareness of STEM skills and ability to perform highly in STEM subjects
- **STEM outcome expectation beliefs**: individual beliefs in the chance to succeed in STEM subjects and careers.

STEM self-efficacy and outcome expectations are shaped by the type of STEM exposure that individuals experience. These are known in the SCCT as "**STEM learning experiences**". STEM learning experiences occur throughout adolescence, and mostly within the school (e.g., through exposure to real-life examples, on-site visits) and the family (through parents in STEM, exposure to digital tools for learning or leisure). The extent to which STEM learning experiences shape individual self-efficacy and outcome expectations depends on a set of **individual and contextual factors**. As for individual factors, individual ability and aptitudes towards STEM subjects are likely to play a role. As to contextual factors, family background (e.g., family financial resources) and general society beliefs regarding women in STEM can influence girls' STEM interests and career aspirations.

The SCCT guides the analysis within the study, from the organisation and analysis of the literature review to the choice of variables in the statistical analysis. The analysis identifies factors that are significant for girls' aspirations and addresses the following **study questions**:

- **SQ1**: Are there differences among countries regarding girls' STEM career aspirations? *What explanations can be provided for differences at the country/regional level?*

[1] Speech by Commissioner Mariya Gabriel at the ICT/STEM event "The work for future or how to attract young people for careers in ICT and STEM?, URL: https://ec.europa.eu/commission/commissioners/2019-2024/gabriel/announcements/speech-commissioner-mariya-gabriel-ictstem-event-work-future-or-how-attract-young-people-careers-ict_en .

- **SQ2**: What are the main determinants and deterrents of girls STEM career aspirations?
- **SQ3**: What is the role of policies? *Which policies, and at which level (school/national/regional), are they most effective in fostering girls' STEM career aspirations?*

Main findings from the research literature

The findings from the literature confirm some of the hypotheses of the SCCT:

- There is strong evidence that **STEM self-efficacy** is highly correlated with, and in some cases gives rise to, both girls' and boys' achievement.
- There is evidence that positive **STEM learning experiences** at school and within the family have a positive effect on interests in STEM. At the school level, enquiry-based STEM teaching and the use of real-life applications are all effective ways to spur both boys and girls interests in STEM. Extra-curricular activities aimed at girls can increase their interest in STEM subjects. Within the family, there is a link between parents in STEM occupations, their performance in scientific subjects and "co-activity" behaviours from the parents' side (e.g., playing maths games, going to science museums) and girls' and boys' STEM aspirations.
- There is less robust evidence of the effect of **contextual factors**. Family socio-economic background is not a factor though some of the experimental research literature provides evidence that parents' and teachers' support shape the development of STEM interests and motivation for girls and boys.

The literature also explored the role of **policies and initiatives** (mainly at the school system level and school level) in influencing and changing students' (and in particular girls') career choices. While the level of standardisation and vocational orientation of the educational system does not seem to play a relevant role, policies at the school-level that influence the learning experience (e.g., career guidance, counselling, exposure to role models and real-life experiences) are considered effective in increasing girls' interest in STEM, although the quality of evidence could be improved to test the effectiveness of changing STEM teaching methods.

Data analysis

The statistical analysis uses OECD PISA 2018 microdata. PISA data is collected from samples of 15 year olds in over 80 countries every three years. It includes their results from reading, maths and science tests along with contextual information about the participant's school and family. In 2018, it included a question on aspirations and interests, asking: "*What kind of job do you expect to have when you are about 30 years old?"*. The professions that students indicated are classified as STEM, ICT, or Healthcare professions, using the ISCO codes provided in PISA.

Our **definition of STEM** starts from the definition of STEM used by OECD, which includes science and engineering professionals and associate professionals, health professionals and ICT professionals. We depart from the OECD definitions in two important ways:

- We **exclude health professionals from the OECD definition of STEM**
- **We exclude ICT professionals from the definition of STEM** but carry out a separate analysis where feasible because gender gaps in career aspirations in STEM and ICT appear to be very different at country level.

The data analysis consists of a **descriptive analysis** to explore the main patterns and correlations among variables of interest and an **econometric analysis** (country-by-country logistic regression and multi-country, 3-level linear probability models) to study the drivers of girls' and boys' career aspirations in STEM and ICT, holding other factors constant. In the multi-country models, the analysis controlled for country-level variables that proxy gender differences in the labour market for STEM, characteristics of the school system, and general level of teachers' digital skills.

Descriptive analysis

This finds that:

- On average, girls are less likely than boys to aspire to STEM or ICT professions, while they are more interested than boys in healthcare professions.
- The average gender gap in STEM and ICT career aspirations is negative and statistically significant across all EU27 and the UK, except Bulgaria, where the gap in STEM is negative but not statistically significant.
- The countries with the largest gender differences in terms of career aspirations in STEM tend to have smaller gender gaps in ICT aspirations.
- Countries with a long tradition of depth STEM teaching at school (largely Eastern and Central European countries) have small gender differences in STEM aspirations, and large differences in ICT aspirations.
- Girls aspiring to STEM careers are better performers in science than girls with non-STEM career aspirations and boys with STEM career aspirations. This result (further confirmed in the econometric analysis) suggests that gender gaps in aspirations cannot be explained by gaps in science performance.

Econometric analysis

The **econometric analysis** sheds light on the potential drivers or deterrents of girls' career aspirations, holding other factors constant. The most relevant results from the econometric analysis are:

- PISA **science competences** are strong predictors of STEM and ICT career aspirations. The effects are stronger though for boys than for girls.
- **Students' level of motivation** appears to drive both girls' and boys' career aspirations in STEM, but more strongly for boys. No relevant effect is found for ICT career aspirations.
- Having a **parent in STEM** is still a strong predictor of both girls' and boys' career aspirations in STEM and ICT. Again, the effects are stronger for boys than for girls.
- A higher **degree of gender equality in the labour market for STEM** contributes to narrowing down the gap in STEM career aspirations, but not the gap in ICT career aspirations.

Overall, it seems that the differences in aspirations cannot be narrowed by acting on the individual factors, as these have a stronger influence for boys than for girls. Policy intervention should aim at increasing the effect of these factors on girls, through increasing girls' interest and making STEM professions as attractive to girls as they are to boys.

Conclusions and policy pointers

The results of this study are expected to take forward the intentions set out by the recent Council Resolution on the framework for cooperation in education and training towards the European Education Area and the Skills Agenda in relation to gender equality in occupations. Specific policy pointers should contribute to the actions planned by the 2020-2025 Gender Equality Strategy[2] and the Women in Digital Initiative which are currently active European initiatives.

The results can identify initiatives that are more and less likely to be beneficial in reducing the gap in STEM and ICT aspirations reflecting on the availability of material in the research literature and the extent that this has been able to address the research questions. The results show that policies aiming at reducing the gap in STEM aspirations and participation should not focus on (or not only on) improving science performance or motivation among girls. Policy initiatives should rather aim at building a stronger link between individual factors and the choice of a STEM or ICT career for girls. These initiatives can be promoted at the EU, Member State and school level, and are illustrated below.

EU-level

Possible policy initiatives at the EU level are:

- Promotion of **in-depth research at the country-level** which focuses on so-far less explored cultural and institutional barriers of girls' aspirations and access to STEM and ICT, such as curriculum content, role models and the organisation of the science curriculum through compulsory education. This research should highlight examples of good practices and their applicability in other Member States, which can provide evidence for the formulation of targeted policy recommendations.
- Funding of process and impact evaluations of pilot initiatives which address the barriers to girls' aspirations and access to STEM and ICT applied in a sample of Member States. This research would establish which initiatives work effectively and how best to implement them.
- Use of existing EU funding programmes to **finance initiatives at the Member State level** to improve girls' perceptions of STEM and mitigate the influence of stereotypes. For example, the Girls4STEM pilot[3], financed through the Erasmus+ programme, focused on the dissemination of gender diversity and awareness raising material for teachers, to help them boost gender diversity in STEM teaching.
- Direction of HORIZON 2020 programmes and projects towards participating in school visits and events in Member States to promote careers for girls in STEM with female role models.
- Organisation of **awareness-raising campaigns** or the support of awareness-raising initiatives at the Member State level that aim at conveying a more gender-diverse image of STEM professions and contribute to inform girls throughout their compulsory education about the wide range of professional opportunities available in the STEM field and the wide range of requirements for entry.

[2] 2021/c 66/01 in which strategic priority 1 includes 'dissolving gender stereotypes' and achieving gender balances in occupational areas.
European Commission (2020), A Union of Equality: Gender Equality Strategy 2020-2025, available at: https://ec.europa.eu/info/policies/justice-and-fundamental-rights/gender-equality/gender-equality-strategy_en
European Commission (last updated December 2020), Women in Digital, available at: https://ec.europa.eu/digital-single-market/en/women-digital-0

[3] https://www.gender4stem-project.eu/

System and school level

Member States and other system level authorities can adopt policies and initiatives that reinforce those above which could be taken forward at the EU-level, and work in close cooperation with schools on their design and implementation. These could include establishing sustainable initiatives which are known to work, supporting the evaluation of pilots and the sharing of results, and promoting STEM and ICT careers to girls.

In addition, possible policy initiatives could include:

- Introduce mandatory **career counselling** for all schools, and, if needed, promote targeted career counselling for girls to inform them about the wide variety of STEM and ICT professions.
- Ensure career information, advice and guidance within early years and primary education challenges occupational stereotypes which some children have inculcated from an early age and promotes careers in STEM and ICT and the educational pathways to achieving them.
- Make **gender-sensitive training part of teachers'** and career **counsellors' training**. This is important to avoid teachers and counsellors (consciously or unconsciously) conveying their stereotypical beliefs to students. This is also particularly relevant in light of the gender-biased influence of parents on girls' STEM aspirations. Gender-sensitive training should be offered to teachers and counsellors in schools as part of their continuing professional development.
- **Foster cooperation between schools and organisations in the public and private sectors** to increase girls' exposure to STEM and ICT jobs, e.g., through on-site or virtual visits and job-shadowing opportunities. These initiatives should be targeted specifically to girls, because they tend to be considerably less exposed to these career opportunities than boys.
- **Support school initiatives to increase exposure to female STEM role models**, through the organisation of school-events where female STEM professionals or students are invited to talk about their professions or studies. If males are included, there should always be gender equality in numbers. These interventions have been shown to be effective, not only in spurring girls' interests in STEM, but also to mitigate gender stereotypes among boys, with potential peer-level spill-over effects.
- Provide **guidelines to schools on the use of textbooks** and other resources that teach STEM and ICT subjects in a more gender-diverse way, i.e., providing equal numbers of female and male role models, matching boys' stereotypical interests with those of girls', e.g., through examples of applications of science and technology to life-science and climate change, or that promote the creativity of STEM subjects.

Value of STEM and ICT professions need to be made more visible/highlighted to girls: STEM and ICT professions should be treated separately, whilst emphasising co-dependencies as Mathematics is a common denominator.

For policy orientation, STEM occupations may be high end and specialised or service oriented. The breadth of STEM and ICT occupations needs to be made clearer so that girls do not think that they need to be top performers to enter these fields and that interdisciplinary and creative thinking capabilities are also routes to these jobs.

At EU level, data collection, monitoring and evaluations should start to look at STEM and ICT separately, and consider health occupations apart.

The importance of STEM and ICT and links to SDGs, and especially involvement of girls and women in climate change must be supported as cohesive policies aligned at regional, national and EU levels.

Policy orientation: promotion of more collective competition type activities such as hackathons and project based competitions that are more conducive for girls.

Policy orientation: confirmation of school and formal learning setting as an important venue for confidence building.

Consider a point on Intergenerational transmission of STEM Gender stereotypes and gender bias and how curricula and pedagogy on this aspect may be developed and integrated in lesson plans.

1 Introduction

This is the final report for the DG EAC study on "Girls' career aspirations in STEM".

Using the insights of relevant literature and a thorough analysis of OECD PISA 2018 microdata, the study investigates the determinants and deterrents of Girls' career aspirations in STEM and draws relevant policy conclusions. The results of the study will be disseminated after a validation workshop with key DG EAC stakeholders through a variety of channels including social media and at a lunchtime conference hosted by the Commission.

This is a timely and important study. As Commissioner Mariya Gabriel noted in her speech at the ICT/STEM event "The work for future or how to attract young people for careers in ICT and STEM?": "*In particular, only one in three STEM graduates is a woman. On average, women make up only 17% of tech-sector jobs*."[4] Faced with such a gap in the representation of females in the STEM professions, understanding girls' career aspirations and the motivations for their decisions during their teenage years and before they choose to specialise in tertiary education is a key prerequisite to tackle inequalities in career choices in order to achieve a gender-neutral economy, as intended by the recent Council Resolution on the framework for cooperation in education and training towards the European Education Area and planned by the 2020-2025 Gender Equality Strategy.[5]

The topic of gender differences in STEM education was addressed by the European Commission in the Education and Training Monitor (2017)[6]. The present study will complement and update the previous findings using the most recent wave of PISA data.

This interim report is structured as follows:

- **Section 2** introduces the background of the study, providing the motivation for studying the topic of girls' career aspirations in STEM.
- **Section 3** presents a detailed conceptual framework for the study. The conceptual framework is based on the Social Cognitive Career Choice Theory (SCCT), which will guide the organisation of the findings of the literature, the formulation of the study questions and the empirical analysis. Based on the conceptual framework, the study questions are then formulated.
- **Section 4** presents the results of the literature review conducted at the inception phase. The considerations drawn from the literature will guide the interpretation of the statistical analysis and the formulation of emerging conclusions.
- **Sections 5 to 6** present the PISA 2018 data analysis results.
- **Section 7** concludes by discussing the results of the statistical analysis by study question and drawing out policy pointers.

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[4] Speech by Commissioner Mariya Gabriel at the ICT/STEM event "The work for future or how to attract young people for careers in ICT and STEM?, URL: https://ec.europa.eu/commission/commissioners/2019-2024/gabriel/announcements/speech-commissioner-mariya-gabriel-ictstem-event-work-future-or-how-attract-young-people-careers-ict_en .

[5] 2021/c 66/01 in which strategic priority 1 includes 'dissolving gender stereotypes' and achieving gender balances in occupational areas.
European Commission (2020), A Union of Equality: Gender Equality Strategy 2020-2025, available at: https://ec.europa.eu/info/policies/justice-and-fundamental-rights/gender-equality/gender-equality-strategy_en

[6] European Commission (2017), Education and training monitor, Luxembourg, publication office of the European Union, available at: https://op.europa.eu/en/publication-detail/-/publication/38e7f778-bac1-11e7-a7f8-01aa75ed71a1 .

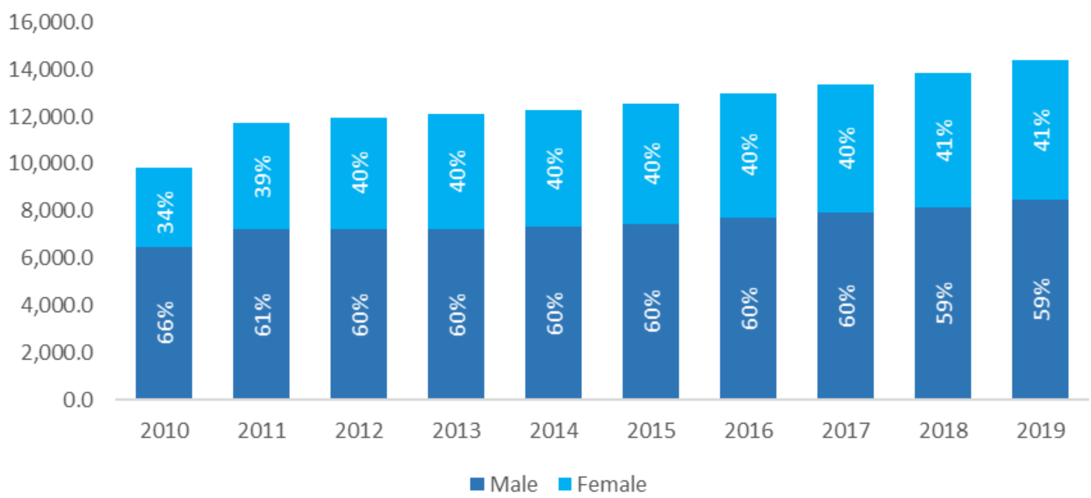
2 Background of the study

2.1 Rationale for the study

There are a range of compelling reasons for seeking to reduce the gender gap in STEM occupations in the EU. Three key reasons are summarised below.

- **Increasing the labour supply in STEM sectors.** STEM skills are critical to innovation and providing a competitive edge in knowledge-intensive economies. However, there have long been shortages of STEM skills across the EU, due to the rising demand for STEM graduates and insufficient numbers of graduates (entry requirements and dropout rates are high and the participation of women is low in STEM degrees)[7]. Despite this, jobs in STEM are forecast to rise by as much as double the rate of other occupations in some European countries[8]. Attracting more females into STEM education and subsequent employment could help to address labour supply and skills shortages in STEM occupations by broadening the pool of applicants and recruits[9][10]. For example, the growth in employment of scientists and engineers in the EU27 over the last decade has increasingly relied on recruiting women, as shown in Figure 1 below.

Figure 1. Employment of scientists and engineers in the EU27 by gender, 2010-2019



Source: Eurostat, Human Resources in Science and Technology. Online data code [hrst_st_nsecsex2]

[7] European Commission, Directorate General for Education, Youth, Sport and Culture (2020) Education and Training Monitor , Luxembourg, Publication Office of the European Union, available at: https://op.europa.eu/en/publication-detail/-/publication/92c621ce-2494-11eb-9d7e-01aa75ed71a1/language-en

[8] McKinsey (2020), The future of work in Europe – Automation, workforce transition and shifting geography for employment Available at: https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Future%20of%20Organizations/The%20future%20of%20work%20in%20Europe/MGI-The-future-of-work-in-Europe-discussion-paper.pdf .

[9] Gonzalez, H. B., & Kuenzi, J. J. (2012), Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer. Washington, DC, Congressional Research Service, Library of Congress. Available at: https://fas.org/sgp/crs/misc/R42642.pdf

[10] ICF & Cedefop (2014), EU Skills Panorama (2014) STEM Skills Analytical Highlight. Brussels: European Commission. Available at: http://skillspanorama.cedefop.europa.eu/sites/default/files/EUSP_AH_STEM_0.pdf .

- **Increasing women's access to well-paid jobs.** Equally important is the recognition that a higher representation of women in STEM would also help contribute to greater overall gender equality in pay. Women are often overrepresented in graduate occupations which are lower paid and underrepresented in occupations which are higher paid. Given that STEM occupations are some of the best paid and most prestigious jobs, the underrepresentation of women in particular fields of STEM contributes to the reproduction of gender inequalities. Indeed, Francesconi and Parey (2018) found, in an analysis of six cohorts of university graduates in Germany, that the single most important contribution to the mean level of gender earning gaps across all graduation cohorts is the field of study, the largest differences observed in economics/business and STEM subjects[11].
- **Avoiding talent loss to drive innovation and growth.** A higher representation of women in STEM occupations could have a strong positive impact on gross domestic productivity (GDP) and lead to a stronger European economy[12]. One estimate, illustrated in ☐, shows that closing the gender gap in STEM could contribute to an increase in EU GDP per capita by 0.7-0.9 % in 2030. By 2050, the increase would be between 2.2 % and 3.0 %. In monetary terms, closing the STEM gap would lead to an improvement in GDP by EUR 610-820 billion in 2050 (the variation in estimates depends on whether closing the gender gap follows a slow or rapid progression).[13]
- **Developing STEM technologies that are not gender-biased and hence do not contribute to increasing gender differences and spreading gender-stereotypes in society.** A notable example of STEM technology that has been found to be gender-biased is Artificial Intelligence. Typical AI products, e.g., search engines[14], have been found to return results that reflect given gender stereotypes, e.g., returning the image of a women for 'nurse or 'go shopping' and that of a man for 'doctor' or 'work'. Recruiting tools that use algorithms to automatically select job candidates can be gender-biased if the data they learn from are based on information gathered on samples of men only.[15]There is an ongoing debate as to whether the underrepresentation of women among AI researchers and professionals might be linked to the gender-bias of some AI products.[16]

[11] Francesconi, M. and Parey, M. (2018), Early gender pay gaps among university graduates, *European Economic Review*, *109*, 63-82.

[12] European Gender Equality Strategy (2020).

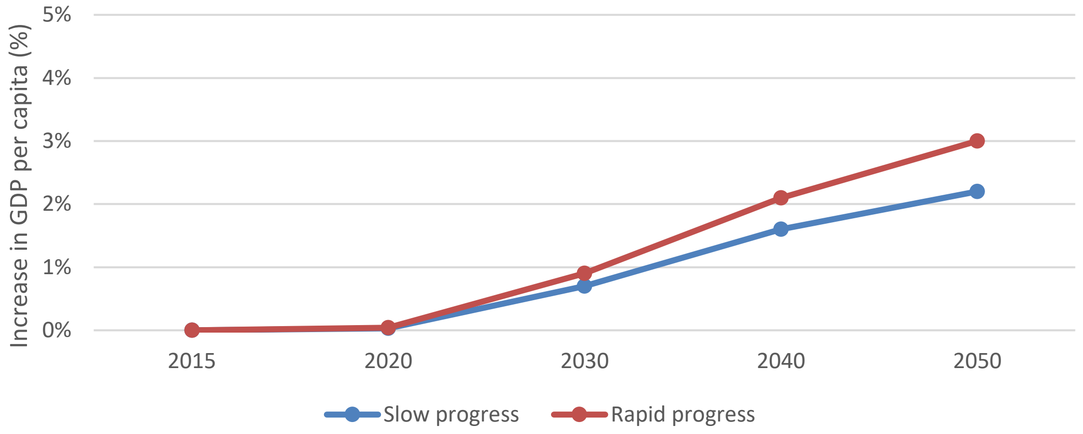
[13] European Institute for Gender Equality (2017), *Economic benefits of gender equality in the EU: How gender equality in STEM education leads to economic growth*, Available at: https://eige.europa.eu/publications/economic-benefits-gender-equality-eu-how-gender-equality-stem-education-leads-economic-growth

[14] Kay, M., Matuszek, C. and Munson, S.A. (2015), Unequal representation and gender stereotypes in image search results for occupations, In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 3819-3828).

[15] See https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G for a notable case reported in the press on Amazon.

[16] See, for instance, Advisory Committee on Equal Opportunities for Women and Men (2020), *Opinion on Artificial Intelligence – opportunities and challenges for gender equality*, available at: https://ec.europa.eu/info/sites/info/files/aid_development_cooperation_fundamental_rights/opinion_artificial_intelligence_gender_equality_2020_en.pdf; Emilia Gomez (2019), *Women in Artificial Intelligence: Mitigating the gender-bias*, JRC Science Hub Communities, HUMAINT project blog 11/03/2019, available at: https://ec.europa.eu/jrc/communities/en/community/humaint/news/women-artificial-intelligence-mitigating-gender-bias.

Figure 2. GDP Impact of closing gender gaps in STEM education.



Source: European Institute for Gender Equality, 2017.

2.2 How underrepresented are girls in STEM courses and careers?

The underrepresentation of girls in STEM varies according to fields of study.

- In upper secondary vocational education for example, girls represented on average 16% of the population of new entrants across the following key STEM fields[17]: natural sciences, mathematics, statistics, engineering, manufacturing, construction and information and technologies in 2018. However, there are significant variations across disciplines. As Figure 3 shows, 41% of new entrants in natural sciences, mathematics and statistics are women in upper secondary vocational education. But only 12% of new entrants are women in engineering, manufacturing and construction and 16% in information and communication technologies (ICT). Germany, Italy, Poland, and Belgium had the highest number of female new entrants in upper secondary education for natural sciences, mathematics and statistics. No female new entrants were recorded in these fields in upper secondary education in various Member States, including Denmark, Estonia, Greece, Cyprus, Croatia, Lithuania, Romania and Sweden in 2018 according to Eurostat[18].
- In tertiary education on average about 31% of new entrants on programmes in three key STEM-related fields[19] were female according to the latest available EU27 average from 2018[20]. As with upper vocational education, there are clear variations in the gender balance across STEM fields at the tertiary level, as figure 2.3 illustrates. While women represent 49% of students in natural sciences, mathematics and statistics; they account for 26% of students in engineering, manufacturing and construction and 18% of students in ICT.
- Women are also underrepresented in many STEM careers in the labour market. While on average about 52% of people employed in science and technology

[17] Eurostat. Online data code: educ_uoe_ent02. Last update 30 May 2020.

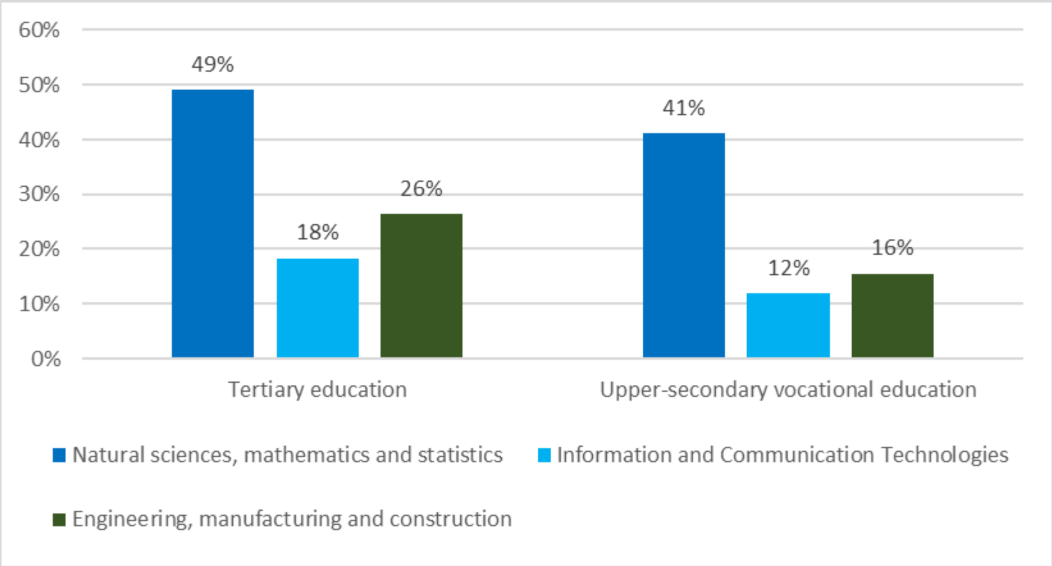
[18] New entrants by education level, programme orientation, sex and field of education, Eurostat. Online data code: educ_uoe_ent02. Last update 30 May 2020.

[19] Average for Natural Sciences, Mathematics and Statistics; Engineering, Manufacturing and Construction; and Information and Communication Technologies. Eurostat. Online data code: educ_uoe_enrt03.

[20] However, women are slightly overrepresented in tertiary education generally; on average 54% of students enrolling in tertiary education are female for all fields of study according to Eurostat.

sectors in the EU27 were female in 2019[21], they are considerably underrepresented in key professional careers and high value sectors. For example, only 41% of scientists and engineers working in the EU27 were female in the same year. Furthermore, just 21% of scientists and engineers in high-technology sectors were female and 18% in high and medium high technology-manufacturing were female in the EU27.[22] Similarly, Eurostat estimates that just 18% of ICT specialists working in the EU27 labour market were female in 2019.[23]

Figure 3. Share of female enrolments on programmes in three STEM fields across the EU27



Source: Eurostat, New entrants by education level, programme orientation, sex and field of education. Online data code: [educ_uoe_ent02]

[21] Eurostat, Employed Human Resources in Science and Technology (HRST) by category, sex, age and NACE Rev. 2 activity (from 2008 onwards), online data code: hrst_st_nsecsex2.

[22] Eurostat: Employed HRST by category, sex, age and NACE Rev. 2 activity (from 2008 onwards), online data code: hrst_st_nsecsex2.

[23] Eurostat, Employed ICT Specialists by sex, online data code: isoc_sks_itsps.

3 Conceptual framework

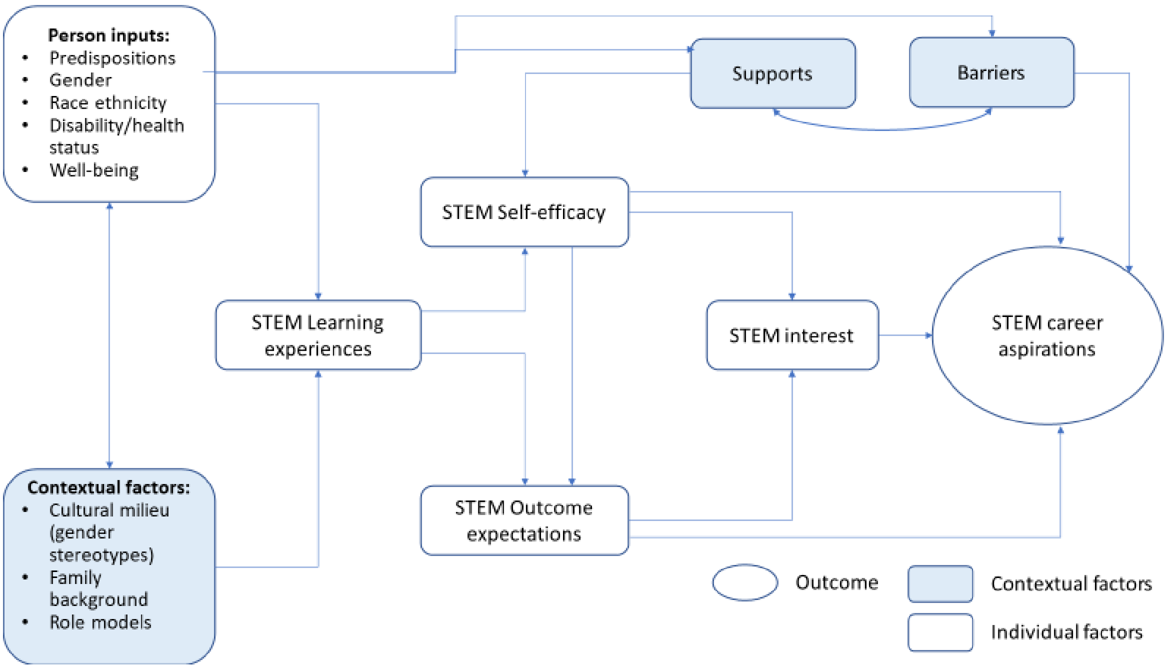
Our analysis of the determinants and deterrents of girls' career aspirations in STEM is framed within the theoretical principles of the Social Cognitive Career Theory (SCCT, Lent et al, 1994). This comprehensive theoretical approach identifies some of the key factors that influence the formation of adolescents' career interests and goals. Besides offering solid theoretical principles on which to base our analysis, the SCCT suggests interesting connections between key factors influencing girls' STEM career aspirations and areas for policy intervention. Hence, the SCCT will also guide the formulation of policy recommendations that are coherent with the overall analytical approach of the study.

SCCT models and explains three aspects of career choice:

- The development of academic and career interests (the "Interest Model")
- How career choices are made (the "Choice Model")
- Educational and career performance and achievement (the 'Performance Model')

Figure 4 summarises the three models of the theory. For the purpose of this assignment, only the first two models will be relevant (i.e., the "interest model" and the "choice model") and will be applied to the case of girls STEM career aspirations, as described in the next sections and in Figure 4 below.

Figure 4. The Social-Cognitive Career model for girls' STEM career aspirations



3.1 A Social Cognitive Career Theory of girls' STEM interests and career aspirations[24]

According to SCCT, and as illustrated in Box 3.1 below, the formation of STEM career interests and aspirations among adolescents is a complex process that involves the interplay of cognitive, background and contextual factors. The effect of these factors is not unilateral, as feedback effects can occur among different determinants.

Following SCCT, the development of STEM interests is directly linked to two main cognitive factors:

- **STEM self-efficacy beliefs**: individual self-awareness of STEM skills and ability to perform highly in STEM subjects.[25]
- **STEM outcome expectation beliefs**: individual beliefs in the chance to succeed in STEM subjects and careers.

STEM self-efficacy and outcome expectations are highly intertwined, in that individuals will be more likely to believe in their chances of success in STEM if they are confident about their STEM skills.

In turn, STEM self-efficacy and outcome expectations are shaped by the type of STEM exposure that individuals experience. We refer to the exposure to STEM-related activities as "**STEM learning experiences"**. These can occur throughout adolescence, and mostly within the school and the family.

Examples of positive STEM learning experiences **within the school** are, the exposure to engaging teaching methods for STEM subjects (e.g., inquiry-based STEM teaching[26], bringing real-life applications to the classroom[27] or hands-on activities in STEM laboratories[28]). The links schools have with the labour market (e.g., through the possibility of visiting STEM companies while studying or doing internships) may also create additional positive learning experiences. In this respect, schools with higher links to the STEM workplace may offer better STEM learning experiences to their students.

Within the family, pupils may be exposed to STEM activities if their parents or relatives are employed in STEM professions. Moreover, exposure to digital tools, e.g., for learning or for leisure, is also a type of learning experience that can enhance digital competences and let individuals gain confidence in their STEM skills. Exposure to STEM activities helps pupils to develop performance goals. Success or failure in performance in STEM can reinforce or weaken individual self-efficacy and outcome expectations beliefs, in a constant feedback loop.

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[24] This section draws from Lent, R. W., Brown, S. D., and Hackett, G. (1994), Toward a unifying social cognitive theory of career and academic interest, choice, and performance, Journal of Vocational Behavior, 45, 79-122 and Lent, R. W., Brown, S. D., and Hackett, G. (2002), Social Cognitive Career Theory, in *Career Choice and Development*, 4th Edition, Jossey-Bass.

[25] The concept of self-efficacy was first introduced in Bandura (1997), Self-efficacy: The exercise of control. New York: Freeman

[26] UNESCO (2017), *Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering and Mathematics (STEM),* Paris.

[27] Taskinen, P. H., Schütte, K., and Prenzel, M. (2013), Adolescents' motivation to select an academic science related career: the role of school factors, individual interest, and science self-concept*, Educational Research and Evaluation,* 19, 717–733.

[28] Lee, M. K., and Erdogan, I. (2007), The effect of science-technology-society teaching on students' attitudes toward science and certain aspects of creativity, *International Journal of Science and Education*, *29*, 1315–1327.

The extent to which STEM learning experiences can shape individual self-efficacy and outcome expectations depends on a set of **individual and contextual factors**. With **individual factors**, individual ability and aptitudes towards STEM subjects are likely to play a role, as well as the overall level of individual well-being or anxiety (especially around learning STEM subjects). In addition, individual factors that influence self-efficacy in all subjects (not only STEM) can be assumed to be relevant also in this context: e.g., health/disability status, migration background.

Contextual factors come into play at two stages of the process. As individuals develop their interest in STEM subjects and as they develop STEM career aspirations. At both stages contextual factors can determine the rise of gender gaps in STEM. They can be family or societal factors.

As to **family-factors**, parental socio-economic background is linked to access to financial and cultural resources that can influence the quality of education received. Moreover, the extent to which parents take an active interest in their children's education and learning matters in guiding them towards understanding their true abilities. Also, the family is the place where adolescents find their main role models, and where stereotypes regarding the different degree of adequacy of boys and girls for becoming STEM professionals can be questioned or perpetuated. Outside the family, positive or negative role models (e.g., teachers or peers) are also crucial in shaping the effect that STEM learning has on self-awareness of STEM ability. In simple terms, negative role models may 'neutralise' the motivating effect of STEM learning experience on the growth of STEM interests and aspirations, while positive role models (e.g., a female STEM teacher, a parent who is a STEM professional) may help instil confidence in girls about their STEM subject ability.

Once pupils have developed an interest in STEM, there is still room for contextual factors to play a role and hinder or favour the formation of career aspirations, hence acting as 'supports' or 'barriers' for career motivation. The poor representation of women in STEM in the area where girls live and in the social media, may discourage them from pursuing a career in this field, thus self-perpetuating the gender gaps in STEM. In addition, the tendency to follow the choice of peers can shape girls' motivation against a career in STEM.

To summarise, individual and contextual factors mediate the effect of STEM learning experiences, which influence STEM self-efficacy and outcome expectation beliefs. These in turn influence interests and aspirations.

> *For example, a young girl from an affluent background is taken to science museums, encouraged to read and learn about science and famous scientists, and given opportunities to take science classes and to attend summer science camp. These learning experiences, afforded by her socioeconomic status, influence the development of her beliefs in her ability to do well in science. Her performance in science and her knowledge that doing well in science will lead to positive outcomes, such as good grades, parental approval, and time spent with friends, lead to the development of her interest in science. She believes she can do well in science in college, she learns that science is a field that is well compensated and one that is not typical for women, and she develops an intention to enter a science major in college.*

Fouad, N. A. (2014)[29]

[29] Fouad, N.A. (2014), Social Cognitive Career Theory Introductory Review, in *Career Theory and Practice: Learning through case studies*, 3rd Edition.

Box 3.1 The Social Cognitive Career Theory: an overview

Social cognitive career theory (SCCT) (Lent et al, 1994, 2002[30]) is a three-tier theory developed to explain:

- How academic and career interests develop (The interest model)
- How educational and career choices are made (The choice model)
- How academic and career success is obtained (The performance model)

Three explanatory factors play a prominent role in this theory: self-efficacy beliefs, outcome expectations, and goals.

Self-efficacy beliefs refer to an individual's personal beliefs about his or her capabilities to perform given tasks or courses of actions. It differs from general individual self-esteem or confidence, as individual self-efficacy beliefs can change based on the activity domains to which it applies. For example, individuals can be confident to achieve good results in research occupations, and less confident of their capabilities in managerial occupations.

Outcome expectations refer to beliefs about the consequences of a given choice or behaviour.

Personal goals are individuals' intentions to engage in a particular activity or to achieve given results. Based on SCCT, goals are connected to both self-efficacy and outcome expectations: People tend to set goals that are consistent with their views of their personal capabilities and of the outcomes that they expect to achieve. Success or failure in reaching personal goals, in turn, can alter or confirm self-efficacy beliefs and outcome expectations.

Interest Model

According to SCCT, individual interests in a given academic or professional career are the direct consequence of self-efficacy and outcome expectations. Over the course of childhood and adolescence, people are exposed, directly and indirectly, to a variety of activities that are relevant to their future occupations and become engaged and interested in given occupational careers. The exposure that individual receive, so-called 'learning experience' is influenced by the context and the culture in which they grow up.

Through continued activity exposure, practice, and feedback, people refine their skills, develop personal performance standards, form a sense of their efficacy in particular tasks, and acquire certain expectations about the outcomes of activity engagement. People are most likely to develop interest in activities at which they both feel skilled and from which they expect positive outcomes. Further activity involvement leads to subsequent mastery or failure experiences that in turn help revise self-efficacy, outcome expectations, and ultimately interests within an ongoing feedback loop.

Choice Model

Career choice goals, i.e., the intention to pursue a given career path are influenced by self-efficacy and outcome expectations. Failure or success to achieve these goals acts as important feedback that can modify or reinforce the initial goals.

[30] Lent, R. W., Brown, S. D., and Hackett, G. (1994), Toward a unifying social cognitive theory of career and academic interest, choice, and performance, *op. cit.*; Lent, R. W., Brown, S. D., and Hackett, G. (2002), Social Cognitive Career Theory, in *Career Choice and Development*, 4th Edition, Jossey-Bass.

SCCT highlights that the influence that individual interests have on the formation of choice goals may be mediated by a number of environmental (or contextual) factors. These factors can act as barriers or facilitators for the pursuit of individual goals. For instance, individuals may not be able to follow their career interests, because they feel that they do not have adequate financial support from their families, or adequate moral support from their group of peers. In such cases, individuals may compromise and choose goals that are less difficult to achieve based on the external environmental circumstances. On the opposite hand, favourable conditions (financial and moral support) allow individuals to follow their career interests more freely.

Performance Model

SCCT's performance model explains to aspects of performance: the level of success that people attain in educational and occupational pursuits and the degree to which they persist in the face of obstacles.

Performance and success are explained in SCCT with the influence of both ability and motivation. Individuals that have a higher level of ability have a higher probability to be top performers. Moreover, partly thanks to the successes obtained, they can develop higher levels of motivation, in the form of self-efficacy, outcome expectations and performance goals.

In addition, SCCT posits that for a given level of ability, higher self-efficacy, outcomes expectations and performance goals have a motivational role per se, i.e., they help individuals to be more motivated, and achieve better results.

3.2 The role of policies in the SCCT model

Through the lens of the SCCT model, it appears that policies can play a role at several stages of the process of the formation of STEM career aspirations. On the one hand, they can create incentives to learn STEM subjects, compensating for the lack of these in the family or in the social environment pupils grow up in. This can be achieved, for instance, through innovative teaching methods promoted at the school level, such as hands-on experience in STEM labs or enquiry-based teaching methods as mentioned above.

On the other hand, policies can help girls to avoid losing interest in a STEM career due to the lack of support in choosing educational paths and job search. Career counselling has proved to be crucial in this respect[31]. In relation to the SCCT it has been argued[32] that career counselling may be pivotal in supporting girls in the consolidation of their interests and in the realisation of their career aspirations, by improving self-efficacy and outcome expectations.[33] Educational policies may also act as barriers for girls' STEM career motivation. For instance, policies that allow access to university only from an academic track require students to take decisions about their educational and professional career at early stages, when they might have not yet developed the necessary self-efficacy.

[31] Herr, E L, Cramer, S H, and Niles, S G (2004), Career guidance and counseling through the lifespan: systematic approaches, Vol. 6. Boston, MA: Pearson Education.

[32] Falco, L. D. (2017), The school counselor and STEM career development, *Journal of Career Development*, 44(4), 359-374.

[33] The assumption here is that career counselling is of good quality and does not exacerbate existing stereotypes

3.3 Study questions

Based on the conceptual framework developed for the study, the main study questions that the present study aims to answer are the following:

- **SQ1**: Are there differences among countries regarding girls' STEM career aspirations?
  - *SQ1.1 What explanations can be provided for differences at the country/regional level?*
- **SQ2**: What are the main determinants and deterrents of girls STEM career aspirations?
- **SQ3**: What is the role of policies?
  - Which policies, and at which level (school/national/regional), are the most effective in fostering girls' STEM career aspirations?

4 Drivers and deterrents of girls' career aspirations in STEM: a literature review

Box 4.1: Main results from the literature

This section looks at the results of the literature in relation to the factors identified by the SCCT that drive career aspirations in STEM:

Table 1. Main findings from the literature in relation to the conceptual framework

SCCT factor	Factor analysed in the literature	Main findings from the literature
STEM self-efficacy and motivation	• Self-efficacy • Competitiveness	• Self-efficacy strongly influences STEM school outcomes. • Competitiveness is shown to be linked to self-efficacy. In experimental studies, it is found to influence outcomes of maths and science tests in experimental settings
STEM learning experiences	• Learning experiences **in school,** e.g.: a) Extra-curricular STEM activities b) On-site visits c) Hand-on experiences d) Enquiry-based STEM teaching methods • Learning experiences in the **family:** a) Parents in STEM b) Parents co-activity behaviours	• Learning activities in school are considered effective in increasing self-confidence in STEM. • Exposure to STEM through the influence of parents who are in a STEM profession appears to be a strong determinant of STEM interests (for boys and girls). • There is evidence of the positive effect of co-activity behaviours (parents engaging in STEM-related activities with their children) being effective in stimulating STEM interests. Results are not specific by gender
Contextual factors	• **Family** • **Teachers** • **Peers**	• No robust findings on the effect of family socio-economic background on STEM

	• **Role models** • **Culture and society**	interests or STEM outcomes. • Experimental studies have found that parents' and teachers' support or pressure can influence self-efficacy in STEM. Girls in particular, are influenced by the beliefs (or gender-stereotypes) conveyed by their mothers. • There is abundant evidence of the role of peers in conveying gender stereotypes in STEM subjects. Peer effects can be generated through gender imbalances in the classroom • In general, studies trying to detect evidence of cultural factors on STEM career aspirations fail to provide strong results.
Policies	• Education system • School policies: a) Exposure to STEM subjects since early childhood b) Exposure to female role models c) Revise STEM teaching methods d) Improving career guidance and counselling	• No evidence of any effect of the education system (e.g., vocational education, level of tracking). • Interventions that increase girls' exposure to female role models in STEM have been found effective in reducing gender stereotypes among boys and girls. • Some literature suggests changing STEM teaching methods to incorporate girls' perspective and reduce gender-bias in textbooks. There is no

		direct evidence of the effectiveness of these initiatives as they have not been tested. • Only a few studies report evidence of the effectiveness of career counselling on STEM self-efficacy. These studies show a positive effect of career counselling interventions that are targeted to increasing STEM career aspirations.

4.1 STEM learning experiences

Following the SCCT, the degree of exposure that adolescents, and especially girls, receive to STEM-related activities plays a role in developing their STEM self-efficacy and outcome expectation beliefs.

The literature offers several examples of effective learning experiences for stimulating interest in STEM. For both boys and girls, extracurricular STEM activities (Heaverlo et al, 2013)[34], enquiry-based STEM teaching (UNESCO, 2017[35]), the use of real-life applications (Taskinen et al, 2013, Kesar, 2018[36]), and 'hands-on' activities (Lee et al, 2007[37]) when teaching STEM subjects seem to result in less fear of failing (or higher self-confidence levels) in scientific subjects and greater motivation to pursue STEM studies. With respect to girls, there is evidence that learning experiences outside school, e.g., summer science camps (Levine et al 2015)[38] and STEM mentoring programmes designed specifically for girls (Stoeger et al., 2013[39]) are effective in improving girls' attitudes towards STEM subjects. Some studies also found a beneficial effect of the exposure to the use of certain types of digital tools, e.g., videogames and

[34] Heaverlo, C., Cooper, R. and Laana, S.F. (2013), STEM development: predictors for 6th-12th grade girls' interest and confidence in science and math, *Journal of Women and Minorities in Science and Engineering*, 19*(2).*

[35] UNESCO (2017), Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering and Mathematics (STEM), Paris.

[36] Kesar, S. (2018), *Closing the STEM gap: Why STEM classes and careers still lack girls and what we can do about it,* Microsoft.

[37] Lee, M. K., and Erdogan, I. (2007), The effect of science-technology-society teaching on students' attitudes toward science and certain aspects of creativity, International Journal of Science and Education, 29, 1315–1327.

[38] Levine, M., Serio, N., Radaram, B., Chaudhuri, S. and Talbert, W., (2015), Addressing the STEM Gender Gap by Designing and Implementing an Educational Outreach Chemistry Camp for Middle School Girls, *Journal of Chemistry Education,* 92(10), 1639–1644.

[39] Stoeger, H., Duan, X., Schirner, S., Greindl, T., Ziegler, A. (2013), The effectiveness of a one-year online mentoring program for girls in STEM, *Computers & Education*, 69.

human robotics, on girls’ STEM interest (see for example, Master et al., 2017[40] and Gomoll et al., 2016[41]).

Given the documented importance that STEM courses, inside and outside school, have on girls’ STEM career motivations, some literature has explored the relationship between curriculum characteristics and the STEM gender gap. McNally (2020)[42] observed that school-tracking systems (e.g., in Austria, Germany, Hungary, and the Slovak Republic) may favour wider gender gaps in STEM, as they affect the offer of courses that pupils receive. It would be natural to ask whether specific curriculum reforms may lead to higher enrolment of girls in STEM subjects. McNally (2020) reports on the findings of three studies evaluating the effect of curriculum reforms in Denmark, the UK and Germany on girls’ propensity to enrol in STEM. In the case of Denmark, the curriculum reform made the high school curriculum less restrictive, allowing students to combine advanced maths with chemistry rather than just physics. The reform increased girls’ propensity to enrol in medicine and technical sciences. In the other countries (UK and Germany) no gender differences in the propensity to enrol in STEM subjects was found. According to McNally (2020), this lack of strong evidence could be attributed to the specificities of these reforms. In all cases, the reforms were not designed to narrow the STEM gender gap. Their aim was just to increase overall enrolment in STEM.

Pupils can be exposed to STEM-related activities also within their families. One straightforward way through which boys and girls can learn about STEM at home is through the influence of a parent who is employed in a STEM occupation. In a recent review of the literature, Plasman et al. (2020)[43] report a consensus across studies (using different methods and focusing on different countries) regarding the connection between STEM parental profession and high-school STEM achievement, for all students in general and for girls (and minority students) in particular. This phenomenon, called the ‘intergenerational transmission of STEM education’[44], can come about through two main channels. First, the day-to-day exposure to STEM at home helps teenagers think of STEM subjects and careers as achievable targets. Second, parents are role models to their children, and it is more likely that boys and girls develop an interest in STEM (and ultimately pursue a career in this sector) if they are trying to follow the example of one of their parents.

Contrary to expectations, there does not seem to be any difference in the effect of a mother or a father in a STEM profession on girls’ STEM achievement. For instance, in a study on mathematic achievement of US children (from childcare to 8th grade), Bowden et al (2018)[45] find a positive transmission of math skills both from fathers to

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[40] Master, A., Cheryan, S., Moscatelli, A. and Meltzoff, A.N. (2017), Programming experience promotes higher STEM motivation among first-grade girls, *Journal of experimental child psychology*, 160.

[41] Gomoll, A., Hmelo-Silver, C.E., Šabanović, S. and Francisco, M. (2016), Dragons, ladybugs, and softballs: Girls’ STEM engagement with human-centered robotics. Journal of Science Education and Technology, 25*(6),* pp. 899-914.

[42] McNally, S. (2020), *Gender differences in tertiary education: what explains STEM participation?*, EENE Analytical Report 41, Prepared for the European Commission, Directorate General for Education, Youth, Sport and Culture.

[43] Plasman, J., Gottfried, M., Williams, D. (2020), Parents’ Occupations and Students’ Success in STEM Fields: A Systematic Review and Narrative Synthesis. *Adolescent Research Review* (2020).

[44] Chise, D, Fort, C and Monfardini, C. (2019), *Scienfico! Like Data On the intergenerational transmission of STEM education in Italy*, IZA DP No. 12688.

[45] Bowden, M. Bartkowski, J.P., Xu X, Lewis R.J (2018), Parental Occupation and the Gender Math Gap: Examining the Social Reproduction of Academic Advantage among Elementary and Middle School Students, Social Sciences, 7(1).

sons and from fathers to daughters. Guo et al (2019)[46] reach similar results in their cross-country analysis of OECD PISA 2015 microdata. Thanks to the cross-country dimension of the data, the authors can explore the interaction between parental STEM profession and the influence of country-level factors. Somehow counter-intuitively, they find that the positive influence of STEM parental occupations on girls' aspirations in STEM is strongest in more developed countries.

Positive STEM learning experiences at home do not occur solely through the effect of STEM parents. Simpkins et al. (2005[47], 2015[48]) look at a comprehensive set of parental behaviours that can foster children's STEM interest and motivation. They report a strong effect of so-called 'co-activity' behaviours, which comprise playing math games, looking at science websites with children, watching science shows, going to science museums, and more. The findings of this study are important as they demonstrate that any family can create a beneficial environment for the growth of their children's STEM interests. Although the study by Simpkins et al (2015) did not focus specifically on girls, one additional result in this study (at the descriptive level) is that girls reported fewer co-activity behaviours by their parents than boys, suggesting that the lack of such learning experiences for girls might play a role in explaining the STEM gender gap.

4.2 Individual background and other personal factors

Individuals differ in their socio-economic background, personality and experiences, all factors that inevitably influence career choices. In this section we will review the findings of the literature on the impact of background and personal attributes on STEM career aspirations.

A strand of the literature has analysed how cognitive ability is related to differences in career aspirations. Research findings are mixed. On the one hand, there is evidence (Wang et al., 2016)[49] that pupils tend to choose careers and majors that are more in line with their cognitive skills. On the other hand, recent empirical evidence on PISA data (OECD 2019)[50] shows that girls have better skill competences in reading and writing rather than in science and maths. However, there is no literature that explicitly links gender differences in cognitive ability with gender differences in career aspirations and uncovers the causal impact of one over the other. As noted by McNally (2020)[51], this might be because it is difficult to disentangle gender differences in measured skills from the influence of other cultural and contextual factors, and hence it would be difficult to find a credible empirical explanation.

Another important personal attribute for the choice of STEM careers seems to be individual degree of competitiveness. Buser et al (2012)[52] explore to what extent

[46] Guo J., Marsh, H.W., Parker, P.D., Dicke, T. and Van Zanden, B. (2019), Countries, parental occupation, and girls' interest in science, *The Lancet Correspondence*, 393*(10171).*

[47] Simpkins, S.; Davis-Kean, P. E.; Eccles, J. (2005), Parents' socialising behavior and children's participation in math, science and computer out-of-school activities, *Applied Developmental Science,* 9*(1).*

[48] Simpkins, S. D., Price, C. D. and Garcia, K. (2015), Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among Latino and Caucasian boys and girls, *Journal of Research in Science Teaching*, 52*(10)*, pp. 1386-1407.

[49] Wang, M.T. et al. (2016), Who chooses STEM careers? Using a relative cognitive strength and interest model to predict careers in science, technology, engineering and mathematics, *Journal of Youth Adolescence*, 14.

[50] OECD, 2019, *Girls and boys performance in PISA*, Paris, OECD Publishing.

[51] McNally, S. (2020), *Gender differences in tertiary education: what explains STEM participation?*, *op. cit.*

[52] Buser, T., Niederle, M. I. and Oosterbeek, H., (2012), Gender, Competitiveness and Career Choices, NBER Working Papers No 18576, National Bureau of Economic Research

gender differences in competitiveness explain gender differences in career choices. They measure competitiveness in an experimental setting. A sample of boys and girls were asked to perform three tasks. The first task was performed under a non-competitive environment, where each participant receives a reward for each problem correctly solved. Then, they performed a similar task in a competitive setting, where only the participant who solved the largest number of problems receives a reward. Finally, participants are asked whether they want to take the final performance under a competitive or a non-competitive setting. The answer to the last question measures their preference for competitiveness. The authors find evidence that different levels of competitiveness between boys and girls explain a large part (up to 23 percent) of the gender differences in career choices. However, as noted by Riegle-Crumb et al. (2019)[53], gender gaps in competitiveness can also be the result of internalised stereotypes (i.e., the belief that competitiveness is a masculine rather than a feminine attribute). In their review of the literature, Niederle and Vesterlund (2010)[54] report the findings of several experimental studies that found that girls do not perform well in competitive maths tests. The gender gap in maths scores changes if the tests are taken in a non-competitive rather than a competitive environment, with girls outperforming boys when tests are taken in less competitive settings (e.g., regular tests at university), and boys outperforming girls in more competitive settings (e.g., an admission test to a prestigious academic institution).

This suggests that gender differences in the level of competitiveness and performance under competition reflect different levels of self-efficacy between boys and girls. There is abundant evidence that self-efficacy is highly correlated with, and in some cases explains, students' achievement, in accordance with our conceptual framework. Studies reviewed by Van Tuijl and van der Molen (2016)[55], which aim to empirically verify the hypotheses of the SCCT, find that self-efficacy developed during early adolescence is an important predictor of later STEM career choices. Recent evidence from PISA data (OECD, 2019) shows that in all OECD countries girls show lower levels of self-efficacy and higher levels of fear of failure in all subjects.

Besides cognitive attributes, the literature has explored the correlation between family background characteristics and past academic performance which could reinforce self-perceptions of individual ability or lead to a revision of outcomes expectations. Family socio-economic background can be an important driver of girls' career aspirations as it can proxy the quality of the learning experience offered to girls at home. In general, the evidence on the influence of socio-economic background is not strong. An earlier OECD report (OECD, 2008) finds that past academic performance is a better predictor of later career trajectories than family background (e.g., family socio-economic status). Among the socio-economic background characteristics, belonging to a minority group adds to girls' STEM disadvantage. For instance, Simpkins et al, 2015[56] report that migrant girls have lower level of family STEM support. There is also abundant literature reporting a larger STEM disadvantage for African American women in the US (see Ireland et al, 2018 for a review of the literature[57]).

[53] Riegle-Crumb, C., Peng, M. and Buontempo, J. (2019), Gender, Competitiveness, and Intentions to Pursue STEM Fields, *International Journal of Gender, Science and Technology*, 11(2), pp.234-257.

[54] Niederle, M. and Vesterlund, L. (2010), Explaining the gender gap in math test scores: The role of competition. *Journal of Economic Perspectives*, *24*(2), pp.129-44.

[55] Van Tuijl, C., and van der Molen, H. W. (2016), Study choice and career development in STEM fields: an overview and integration of the research, op. cit.

[56] Simpkins, S. D., Price, C. D. and Garcia, K. (2015) op cit.

[57] Ireland, D.T., Freeman, K.E., Winston-Proctor, C.E., DeLaine, K.D., McDonald Lowe, S. and Woodson, K.M., (2018), (Un) hidden figures: A synthesis of research examining the intersectional experiences of Black women and girls in STEM education. *Review of Research in Education*, *42*(1), pp.226-254.

4.3 Contextual factors

The literature identifies four orders of contextual factors that may shape the development of girls' STEM interests and aspirations: parents' and teachers' support or pressure, peer effects, teacher effects and societal factors.

4.3.1 Parents' and teachers' support or pressure

A large body of literature emphasises the positive role that parents and teachers can have in early childhood in shaping STEM career decisions (see, for instance, Van Tujil and van der Molen, 2016[58] for a review of the literature).

Parents who endorse gender stereotypes in academic achievement (e.g., that girls are better at English, while boys are better at maths) may convey those beliefs to their daughters and undermine their confidence to succeed in STEM subjects. One channel through which the transmission of stereotypes may take place is the so-called 'intrusive support', i.e., parents' uninvited help and monitoring with homework. The idea is that, by giving uninvited support, parents express their belief that their children cannot succeed in a subject. Bhanot and Jovanovic (2005)[59] conducted an experimental study on 8th grade pupils and their families living in rural areas in the US. They found that girls who received parental intrusive support with their maths homework were more likely to report lower ability self-perceptions than boys. The effect was similar for both fathers' and mothers' intrusive support.

Most studies on this topic suggest that the role of mothers might be stronger than that of fathers in shaping children's STEM self-beliefs. One explanation for this recurring finding might be that mothers are traditionally assigned caring responsibilities within the family, and hence spend more time with their children in general (i.e., also on their children's schooling activities). Eccles et al. (2012)[60] find that mothers' beliefs regarding their children's abilities in all subjects are strong predictors of children's motivation and self-beliefs later in adolescence. Some studies also indicate that mothers' influence can be stronger for girls than for boys. For example, an early study on sixth graders by Frome and Eccles (1998) found that girls tended to align their self-evaluation of math skills to the evaluation given by their mothers on their daughters' ability. This led to an underestimation of girls' ability in maths, even within the group of girls with higher maths grades than their classmates. More recently, Leaper at al. (2012)[61] assessed the relative strengths of a set of individual and contextual factors on self-perception of individual ability in different subjects. They analysed a sample of North American 13-18-year-old girls. They found that girls who felt supported by their mothers in maths and science were also more likely to report a higher self-assessment of their abilities in those subjects. Similarly, Hoferichter and Raufelder (2019)[62] analysed a sample of German 8th grades female pupils and found that girls that felt that they had their mothers' support in STEM subjects also had better grades in STEM subjects.

Besides parents, teachers may also provide pressure or support on pupils and convey gender biased opinions about their STEM skills. Gunderson et al. (2012) review the

[58] Van Tuijl, C., and van der Molen, H. W. (2016), op cit.
[59] Bhanot, R., and Jovanovic, J. (2005), Do parents' academic gender stereo-types influence whether they intrude on their children's homework Sex Roles, 52, 597–607.
60 Eccles, J., Simpkins, S., and Fredricks, J. (2012) 'Charting the Eccles' expectancy-value model from mothers' beliefs in childhood to youths' activities in adolescence', Developmental Psychology, 48(4).

[61] Leaper, C., Farkas, T. and Brown, C. S. (2012), Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English, Journal of Youth and Adolescence, 41(3), pp. 268-282.
[62] Hoferichter, F. and Raufelder, F. (2019), Mothers and fathers – Who matters for STEM performance? Gender-specific associations between STEM performance, parental pressure and support during adolescence, *Frontiers in Education*, 4(14).

literature on this topic and report that most studies find that teachers' beliefs regarding their pupils' maths abilities are gender-biased and this can influence boys' and girls' math skills and performance. A study by Ertl et al. (2017)[63] investigated whether having teachers that had stereotypical behaviours influenced girls' STEM self-efficacy at later stages of their school career. They conducted a survey of undergraduate female students in several German universities. The students who participated in the survey were enrolled in programmes where the proportion of females was less than 30 percent. They found that those students who declared that their high-school teachers had stereotypical behaviours (e.g., they encouraged boys to pursue a career in STEM more than they did girls) were also more likely to report lower self-efficacy in STEM. This result shows that the support received from teachers can have long lasting consequences on girls' STEM self-efficacy, even among girls who decide to enrol in a STEM subject at university. In an experimental study on high-school students in Israel, Lavy and Sand (2018) find that gender-bias is reflected in teachers' math grades (girls' grades tended to be higher when the tests were corrected 'blindly', i.e., without knowing the sex of the student) and this in turn has an impact on gender differences in the choice of advanced maths and science courses in high-school.

4.3.2 Peer effects

The influence of peers in the development of teenagers' identity is widely documented in the psychological literature.

Teenagers tend to identify themselves with their "significant others", i.e., their group of friends. This process of identification shapes adolescents' interests, self-beliefs, behaviours, and choices, including academic and career choices.[64] There is vast empirical evidence confirming this hypothesis, in several fields. Regarding STEM interests and aspirations, a study on US adolescents (Jones et al., 2012[65]) finds that perceptions of peers' academic behaviour (how good teenagers perceive their friends to be at school) were positively associated with individual self-perception about their maths ability, and through this to their maths performance. Similarly, a longitudinal study in Sweden (Raabe et al., 2019[66]) finds that girls are more likely to report and to retain an interest in STEM subjects if they share such interest with other girls in their class.

This suggests that, if gender stereotypes about STEM careers are prevalent within the group of peers, it is more likely that girls' and boys' behaviours will mirror those stereotypes. This is a common finding of empirical studies on peer-effects (see Leaper, 2015[67] for a critical review). A study by Riegle-Crumb and Morton (2017)[68] seems to suggest that the transmission of stereotypes through a group of peers may work also in reverse. In a sample on US 8th grade pupils (both boys and girls), the authors find that girls who were exposed to a higher percentage of boys in their classroom who reported to adhere to gender stereotypes in STEM, had a more negative attitude

[63] Ertl, B. Luttenberger, S. and Paechter, M. (2017), The impact of gender stereotypes on the self-concept of female students in STEM subjects with an under-representation of females, *Frontiers in Psychology*, 8.
[64] Ellemers, N. & Haslam, S. A. (2012). Social identity theory. In P. A. M. Van Lange, A. W. Kruglanski & E. T. Higgins (Eds.), *Handbook of theories of social psychology* (Vol. 2, pp. 379–398). Thousand Oaks, CA: Sage Publications.
[65] Jones, M. H., Audley-Piotrowski, S. R., & Kiefer, S. M. (2012). Relationships Among Adolescents' Perceptions of Friends' Behaviors, Academic Self-Concept, and Math Performance. *Journal of Educational Psychology*, 104*(1).*
[66] Raabe, I.J., Boda, Z. and Stadtfeld, C. (2019), The social pipeline: how friend influence and peer exposure widen the stem gender gap. *Sociology of Education*, 92*(2),* pp.105-123.
[67] Leaper, C. (2015) Do I belong?: Gender, peer groups, and STEM achievement, *International Journal of Gender, Science and Technology*, 7*(2),* pp.166-179.
[68] Riegle-Crumb C. and Morton, K. (2017a), Gendered Expectations: Examining How Peers Shape Female Students' Intent to Pursue STEM Fields, Frontiers in Psychology, 8.

towards STEM. On the other hand, girls who were exposed to a higher percentage of confident females in their classrooms reported a positive attitude towards STEM subjects. This finding suggests that, while peers can play a role in perpetuating stereotypical behaviours, they can also support behaviours against prevalent stereotypes which may have been established by and during primary education.[69]

Besides the tendency to align one's behaviour to the expectations of the group, the influence of peers can act through other channels. A vast body of literature has focused on pressure created by the gender composition of the classroom. Shapiro and Williams (2013)[70] argue that in male-dominated classrooms girls may be under a STEM "stereotype threat". This term refers to the anxiety and fear to fail in STEM subjects, and hence to confirm the stereotype that girls are less good in STEM than boys. As we have seen above, such anxiety negatively affects performance, and this might explain why girls perform less well in maths tests than boys.

To further assess the effect of the gender balance of the classroom, research has compared STEM performance and engagement of girls in single-sex and mixed-sex schools (see, for instance, Cherney and Campbell, 2011[71], Park et al, 2012[72] and Forgatz and Leder, 2020[73] for a comprehensive literature review). Overall, none of these studies finds compelling evidence that single-sex schools have a positive effect on girls' STEM engagement. Whenever an effect is found, it appears weaker than the effect of other characteristics. For instance, Barker et al. (2006)[74] report that the positive effect found for single-sex schools may be explained by pupils' socio-economic characteristics: pupils attending single-sex schools typically come from better socio-economic backgrounds[75], which also influence achievement and interests in STEM. From the literature reviewed above, it is also possible that, when a positive effect is found, this is due to positive peer exposure, e.g., in a same-sex schools, girls have higher chance to meet other girls with the same interests or interacting with self-confident female peers.

4.3.3 Role models

As discussed above, both parents and peers can be role models for adolescents, and their influence is crucial to shape STEM self-beliefs and interests.

Role models can also be found outside the family and the group of peers. For the development of girls' interest in STEM, research has shown that the exposure to female STEM professionals and female STEM teachers can help counteract the negative effects of prevalent gender stereotypes. Three interesting experimental studies, described below, focus on exposure to STEM female professional role models.

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[69] OECD, Education and Skills Today (2021), The future at Five: gendered aspirations of five year olds

[70] Shapiro, J., Williams, A. (2012), The Role of Stereotype Threats in Undermining Girls' and Women's Performance and Interest in STEM Fields*, Sex Roles*, 66.

[71] Cherney, I.D., Campbell, K.L. (2011), A League of Their Own: Do Single-Sex Schools Increase Girls' Participation in the Physical Sciences? *Sex Roles* 65.

[72] Park, H., Behrman, J. R., and Choi, J (2012), Do Single-Sex Schools Enhance Students' Stem (Science, Technology, Engineering, and Mathematics) Outcomes? PIER Working Paper No. 12-038, Available at SSRN: https://ssrn.com/abstract=2153812 or http://dx.doi.org/10.2139/ssrn.2153812

[73] Forgasz, H., Leder, G. (2020), VCE STEM subject enrolments in co-educational and single-sex schools, Mathematics Educational Research, 32, 433–448.

[74] *Barker, L. J. and Aspray, W (2006),* The state of research on girls and IT*, in J. M. Cohoon and W. Aspray (eds), Women and Information Technology: Research on Underrepresentation,* London, The MIT Press, pp. 3-54*.*

[75] This may not be the case for all countries.

Breda et a. (2016) evaluated the impact of the French programme 'For Girls and Science', consisting of a one-hour one-off presentation by a female STEM PhD student or professional in a classroom made up of both boys and girls. Their findings show that in general the intervention reduced stereotypical beliefs among students regarding gendered science-related careers. Moreover, the intervention had a positive impact in changing the educational choices of high-achieving girls in 12th grade: within this group, the proportion of girls declaring that they would like to pursue STEM subjects significantly increased after the intervention.

Sout et al (2011)[76] conducted three experimental studies that tested whether exposure to same-sex role models in STEM might increase girls' STEM self-efficacy. The three experimental studies differed in the sample of participants and in the type of treatment that girls received. In the first study, a group of undergraduate women in engineering, chemistry or biology were randomly assigned to having a brief conversation with a male or female mathematician. In the second study, a group of undergraduate women in engineering were randomly assigned to interact with a (male or female) engineer. In the third study, a group of girls who wanted to pursue a major in STEM were taught an introductory calculus course by a (randomly assigned) male or female teacher for a year. In all three cases, the group of girls that had interacted with a same-sex role model had higher STEM self-efficacy after the experiment than the group of girls that interacted with a male role-model. They also put more effort in solving difficult maths tests. In all cases, girls who interacted with a female role model had not changed their stereotypical perceptions of STEM subjects as male subjects. Overall, the findings of this study suggest that, although girls continued to believe that STEM subjects were primarily for men, exposure to same-sex role models counteracted the effect of this stereotypical belief and increased their self-efficacy.

Herrmann et al. (2016)[77] conducted two experiments on female students of two STEM courses characterised either by low pass rates and low grades (introductory psychology) or low female representation (chemistry) in a large North Western American university. In both cases, the experiment consisted in sending a letter from a STEM professional to a randomly assigned group of female students. The letter described the difficulties that the female professional had during her studies, but also how she had overcome them. The letter also depicted the time spent at university as an investment. The results of the experiment showed that reading the letter decreased the failure rates among the students who received the letter and improved the grades of the students.

As mentioned above, teachers can also act as role models for girls. Young et al. (2013)[78] conducted a socio-psychological test (the "Implicit Association Test") among engineering and chemistry students to measure the association between female role models and female attitudes towards science, identification with science and endorsement of gender stereotypes regarding science. They found that female students who saw their female professor as a positive role model (i.e., they reported that they liked their science professor, and they saw their professor as an expert they could rely on, or that they admired their professor) reported a more positive attitude

[76] Stout JG, Dasgupta N, Hunsinger M, McManus MA (2011) STEMing the tide: using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). J Pers Soc Psychol 100:255–270. 10.1037/a0021385.

[77] Herrmann, S.D., Adelman, R.M., Bodford, J.E., Graudejus O., Okun, M.A., Kwan, V.S. (2016), The effects of a female role model on academic performance and persistence of women in STEM courses, Basic Applied Social Psychology 38, 258–268

[78] Young, D. M. Rudman, L.A, Buettner, H.M. McLean, M.C. (2013), Helen M. Buettner, The Influence of Female Role Models on Women's Implicit Science Cognitions, *Psychology of Women Quarterly*, 37.

towards science and lower endorsement of STEM gender stereotypes than female students who had a male professor as a positive role model.

In a longitudinal study of students in public high schools in North Carolina, Stearns et al. (2016)[79] find that female students that graduate from high schools where there is a higher proportion of female maths and science teachers have a higher probability of enrolling in a STEM subject at university. They suggest that increasing the percentage of female STEM teachers in schools may help narrow down the gender gap in STEM, by increasing the exposure to positive female role models.

Riegle-Crumb et al. (2017b)[80] explore the positive effect that the exposure to female STEM teachers has on boys in reducing their endorsement of stereotypical beliefs. Using a survey of students in a high-school advanced engineering class in the US, they found that after one-year exposure to a female engineering teacher, boys who at the beginning of the year endorsed gender stereotypes regarding STEM, significantly decreased their degree of endorsement.

4.3.4 Societal and cultural factors

As we have seen when discussing the conceptual framework of this study, the SCCT model predicts that the social and cultural context in the country or region where girls live will play a role in their career choice and interests by mediating the effects of self-efficacy and outcome expectation beliefs.

Regarding cultural factors, as argued by McNally (2020)[81], the strong effect found in the literature for peers', family and teachers' support already demonstrates that in a gender-biased cultural environment girls will be discouraged from pursuing a career in STEM. McNally (2020) notes that there is no empirical evidence of the influence of 'culture' per se, i.e., separate from the other factors that we have already discussed. This is partly due to the difficulty in defining 'the cultural context' and hence to measure it empirically. Sikora and Pokropek (2012)[82] use the share of females in schools as a proxy for 'feminine culture' in the country. They find that countries with a higher concentration of girls in schools have higher gender-gaps in STEM career aspirations. Among the societal factors, some literature has focused on the relationship between gender equality in a society and the gender gap in STEM enrolment and careers. Using PISA 2015 data, Stoet and Geary (2018)[83] found a negative association between the 'Global Gender Gap Index' (GGGI)[84] and the women to men ratio of STEM graduates in a country. The authors call this result a 'gender equality paradox', as it seems to imply that more gender-equal countries have higher gender gaps in STEM. The authors interpret the finding as evidence that gender differences in STEM might be due to education and career preferences, rather than

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[79] Stearns, E., Bottia, M.C., Davalos, E., Mickelson, R.A., Moller, S. Valentino, L. (2016), Demographic Characteristics of High School Math and Science Teachers and Girls' Success in STEM, 2016, *Social Problems*, 63.

[80] Riegle-Crumb, C., Moore, C. and Buontempo, J. (2017b), Shifting STEM stereotypes? Considering the role of peer and teacher gender. *Journal of Research on Adolescence*, *27*(3), pp.492-505.

[81] McNally, S. (2020), *Gender differences in tertiary education: what explains STEM participation?*, EENE Analytical Report 41, Prepared for the European Commission, Directorate General for Education, Youth, Sport and Culture.

[82] Sikora, J. and Pokropek, A. (2012), Gender segregation of adolescent science career plans in 50 countries. *Science Education*, *96*(2), pp.234-264.

[83] Stoet, G., D.C. Geary (2018). The Gender-Equality Paradox in Science, Technology, Engineering and Mathematics Education. *Psychological Science* 29*(4).*

[84] The GGGI is a composite index developed by the World Economic Forum which reflects equality of opportunities between women and men in different domains (employment, education, politics, well-being), see https://reports.weforum.org/global-gender-gap-report-2020/

overall gender inequality. This finding has been recently criticised by Richardson et al. (2019)[85], who argue that both the GGGI and the measure of STEM gender gap used by Stone and Geary (2018) are highly questionable. They show that by using another measure of STEM gender gap (one that is more commonly used in the literature), the gender equality paradox disappears, and there does not seem to be any relationship between gender equality and STEM gender gap at the country level. Richardson et al. (2019) suggest that the lack of robustness of the results by Stoet and Geary might be due to the effect of unobserved country-level differences that cannot be controlled for in a cross-country study. They recommend addressing the research question of the link between gender equality and STEM gender gap in a longitudinal study. In fact, a study by Anghel et al. (2019)[86] performs a longitudinal analysis using five waves of PISA data (2003 to 2015) and finds that there is no correlation between the GGGI and the gender gap in maths. This confirms that the results found by Stoet and Geary might have been spurious and driven by country-level confounding factors.

Studies using individual level data provide different results. Leaper et al. (2012)[87], found that exposure to feminism, i.e., reported awareness of what feminism is and/or having talked about feminism with someone close (family member or friend), was positively associated with girls' academic motivation in STEM subjects. Using four waves of PISA microdata (2003 to 2012), Nollenberger et al (2016)[88] found that children of parents who come from more gender-equal countries are more likely to report higher self-efficacy in maths. They interpret this result as a cultural effect: families who are from a more gender-equal culture may tend to be less gender biased regarding their children's maths abilities.

4.4 Policies

The literature reviewed so far identifies, implicitly or explicitly, important areas of policy interventions to foster girls' career aspirations in STEM.

Country-level educational policies are believed to influence students' career choices, although the results are often not significantly different by gender.

In their analysis of pupils' STEM career choices using OECD PISA data, Blasko et al. (2018)[89] test whether the level of tracking (or stratification), vocational orientation and standardisation of educational systems may influence STEM career aspirations and the gender gap. Below we summarise their results and compare them with the results of other relevant literature:

- **The level of tracking** of a school system, i.e., the extent to which students are divided into different classes (with different curricula) based on their achievement. Proxied in Blasko et al. (2018)'s empirical analysis by age at first selection and number of school types in a country, the level of tracking of a school system has been shown to increase the influence of parental socio-economic background and teachers' support on students' choices. Studies have

[85] Richardson, S.S, Reichers M. W., Bruch, J., Boulicault, M., Noll, N.E., Shattuck-Heidorn, H. (2019), Is there a gender-equality paradox in Science, Technology, Engineering, and Math (STEM)? Commentary on the study by Stoet and Geary (2018), *Psychological Science – Commentary*.

[86] Anghel, B., N. Rodriguez-Planas, A. Sanz-de-Galdeano (2019), *Culture, Gender and Math: A Revisitation*. IZA Discussion Paper Series IZA DP. 12371

[87] Leaper, C., Farkas, T. and Brown, C. S. (2012), *op. cit.*

[88] Nollenberger, N., N. Rodríguez-Planas and A. Sevilla (2016), *The math gender gap: The role of culture*, American Economic Association, http://dx.doi.org/10.1257/aer.p20161121.

[89] Blasko, Zs., Pokropek, A., Sikora, J.:(2018), *Science career plans of adolescents: patterns trends and gender divide*, EUR 28878 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-76475- 2, doi:10.2760/251627, JRC109135.

also found that in highly stratified systems, students' career expectations tend to mirror better the actual situation in the labour market. Based on the results of these studies, Blasko et al. (2018) hypothesise that girls might be less inclined to choose STEM in countries with very stratified school systems. Their empirical analysis, however, does not find strong confirmation of this hypothesis. Variables proxying stratification are not correlated either to STEM career choices in general or to the gender gaps in STEM career choices.[90]

- **Vocational tracking**, which is part of a stratified educational system, was found to be a significant determinant of career choices.[91] The explanation for this result is that students in vocational tracks are more likely to specialise with a focus on a specific set of jobs. When the selection in vocational tracks happens early it can reflect teachers' and parents' beliefs on what typical occupations for girls are, rather than girls' interests and skills. Hence vocational tracks (before the age of 15) may contribute to widening the gender gap in STEM aspirations. This result is confirmed by country-level research in the EU[92], which further indicates that while vocational track per se may increase vocational interests in STEM, early educational sorting can worsen segregation between schools and curricula and hence worsen the gender gap in STEM education and career aspirations. Overall, the above results suggest that if students attended more similar schools, they would be more likely to make gender-balanced occupational choices.
- **Standardisation** can be of two types: **standardisation of inputs** (teacher training, curricula, textbooks), and **standardisation of output** (national exams). Blasko et al. (2018) report evidence from studies finding that standardisation of outputs may decrease interest and motivation in STEM (through the pressure of meeting high requirements for the exams), and through this, lower girls' STEM career aspirations. In their empirical analysis Blasko et al. (2018) control for standardisation of output with a dummy variable indicating whether the countries have a national compulsory mathematics exam, but this was not found to explain the gender gap in STEM career aspirations. However, other research[93] suggests that there may be a positive association between students' career aspirations in STEM, and compulsory national examinations in mathematics. The necessity of preparing for standardised tests could create opportunities for several students to continue studying STEM-related subjects and choose career occupations in these fields.[94]Hence, across Member States, the existence of standardised mathematics examinations during the end of upper secondary education could promote the career aspirations of students in STEM.

Besides policies at the national level, there are policies specific to the STEM subjects that seem to be effective in fostering girls' career aspirations. These can be implemented both at the national and at the school level:

[90] Some evidence of the effect on stratification on girls' STEM career aspirations where found in Sikora, J. and Pokropek, A. (2012), Gender segregation of adolescent science career plans in 50 countries. *Science Education*, *96*(2), pp.234-264.

[91] Blasko et al (2018) measure the level of tracking with the share of 15-year-old students who are enrolled in a programme whose curriculum is pre-vocationally or vocationally oriented.

[92] European Commission (2018). Science career plans of adolescents: patterns, trends and gender divides. [online]. Available at: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/science-career-plans-adolescents-patterns-trends-and-gender-divides

[94] European Commission (2018), *op. cit.*

- **Exposure to STEM since early childhood**: in the framework of the SCCT, STEM learning experiences are essential to shape girls' STEM self-efficacy and outcome expectations beliefs. In their review of the literature, Baker et al. (2013)[95] report that successful policies have focussed on reforming childcare education, i.e., introduction of STEM teaching and STEM activities in early years education to challenge gender stereotypes. Such policy interventions would require adequate training and professional development for teachers. Baker et al. (2013) also report that studies find a positive effect of exposure to digital tools on girls' attitudes towards STEM. This suggests that policies that aim to increase the use of computers or other digital tools among girls might be effective.
- **Changes in STEM teaching methods**: Policies that target STEM teaching can take two forms. First, alternative methods for teaching STEM could be introduced that expose girls to real-life applications (where they can see the value of STEM professions). Second, curricula and textbooks could be reformed to remove their gender-bias. An OECD (2016)[96] report suggests that reviewing STEM curricula to ensure that they incorporate girls' perspectives could be an effective policy to reduce STEM gender biases in teaching. The results presented in that report show that girls are interested in knowing how STEM can help prevent diseases, while boys are more interested in other STEM topics, e.g., energy and motion. Hence, to raise both boys' and girls' interests in STEM professions, it would be important for curricula to consider boys' and girls' different interests. Kesar (2018)[97] makes a similar point and suggests that it is important to convey the message that STEM professions are 'creative' and that doing STEM can "make the world a better place", as these values are matter for girls in the choice of their future careers. Benavot (2016)[98] suggests that schools should aim to use gender-sensitive textbooks, to avoid instilling gender stereotypes in school-aged children. We have also discussed the possible negative effect of teachers' gender biases. Appropriate teachers' training could be proposed as a policy to tackle their unconscious biases.
- **Exposure to female STEM role models**: Several studies have found a positive effect of exposure to female STEM role models on girls STEM self-belief and motivation. Female STEM teachers or STEM professionals can be positive role models for girls. Stearns et al. (2016)[99], for instance, suggest that the recruitment of more female STEM teachers could have a positive effect on girls' STEM achievements. Policies such as workplace visits and meetings with STEM professionals can be very beneficial for girls' STEM self-belief. They can also reduce the prevalence of gender stereotypical beliefs about STEM careers among both boys and girls.
- **Career guidance and counselling** can provide targeted interventions that can improve individual self-efficacy. Rottinghaus et al (2018)[100] reviewed 39 academic articles which described a total of 153 career counselling measures

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[95] Baker, D. (2013), What works: Using curriculum and pedagogy to increase girls' interest and participation in science, Theory into Practice, 52(1), pp. 14-20.

[96] OECD (2016), PISA 2015 Results (Volume I): Excellence and Equity in Education, OECD, Paris.

[97] Kesar, S. (2018), Closing the STEM gap: Why STEM classes and careers still lack girls and what we can do about it, Microsoft.

[98] Benavot, A. (2016), *Gender Bias is Rife in Textbooks*, World Education Blog.

[99] Stearns, E., Bottía, M. C., Davalos, E., Mickelson, R., Moller, S. and Valentino, L. (2016), *op. cit*.

[100] Rottinghaus, P.J., Falk, N.A., Park, C. J. (2018), Career assessment and counselling for STEM: a critical review, *The Career Development Quarterly*, *66*(1).

and their impact on self-efficacy. The authors report that the SCCT was the most used theoretical framework for the design of career interventions, with 14 articles using this theoretical background. Despite the consensus among specialists regarding the benefits of career counselling, there are very few studies documenting the positive effect of career counselling on STEM self-efficacy. An exception is Falco and Summers (2019)[101], who evaluate the effect of a 9-week career intervention that aimed at increasing girls' STEM self-efficacy. The intervention consisted in a series of 50-minute group counselling sessions where high-school girls received information about STEM careers and exchanged ideas about possible barriers and facilitators for pursuing those career paths. Participants were encouraged to think about examples of success and achievements and how they could apply those previous examples to a career in STEM. Some sessions focused on managing anxiety regarding STEM subjects and on giving participants verbal persuasion and encouragement. At the end of the intervention, the authors find a significant increase of career self-efficacy and STEM self-efficacy among the girls who participated in the group counselling.

[101] Falco, L. D. and Summers, J.J. (2019), Improving career decision self-efficacy and STEM self-efficacy in high-school girls: evaluation of an intervention, *Journal of Career Development*, 46*(1).*

5 Approach to data analysis and results from the descriptive analysis

5.1 Approach to data analysis

5.1.1 Definition of STEM in the data analysis and implications

There is no agreement of what sectors should be included in the STEM definition, both across national policies (e.g., the criteria used for assigning grants) and in the literature. Gonzales and Kuenzi (2012)[102], for instance, note that for the US the definition has changed over time and new fields have been added to the STEM category as needed.

Given this consideration, we have adopted a definition that we think is most indicated for the purpose of this study, i.e., the analysis of gender gaps in STEM career aspirations among adolescents.

Our starting point for the definition of STEM is the OECD definition, which includes science and engineering professionals and associate professional, health professionals and ICT professionals. We have departed from the OECD definitions in two important ways:

- We have **excluded health professionals from the OECD definition of STEM**. The reason is that, while there is a gender gap in the aspirations (and in the labour market) in engineering, technology, mathematics professions, the gender gap is reversed for professions in the healthcare sector. Hence, combining health professionals with other STEM professionals in the definition of STEM would risk providing a misleading picture of the gender gap in STEM.
- **We exclude ICT professionals from the definition of STEM**. The reason is that gender gaps in career aspirations in STEM and ICT appear to have different behaviours, and hence it is interesting to analyse them separately. As this definition deviates from what is done in most studies, it is important to keep in mind that our definition of STEM is different, and that our results are comparable to those of other studies only if results on STEM and ICT career aspirations are looked at together, and not separately.[103]

5.1.2 Construction of the career-aspiration variables

The analysis of gender gaps in career aspirations at the descriptive level is performed for the following groups of students in relation to their answer to the following question in the PISA 2018 student questionnaire: "*What kind of job do you expect to have when you are about 30 years old?*"

- **STEM-career group**: dummy variable equal to 1 if students indicate that their future job will be one of the following ISCO codes: science and engineering professionals (ISCO sub-major group 21), except product garment designers (2163), graphic and multimedia designers (2166); science-technicians and associate professionals, including physical and engineering science technicians (ISCO minor group 311), life-science technicians and related associate professionals (minor group 314), air traffic safety electronic technicians (ISCO 3155).

[102] Gonzales H.B. and Kuenzi, J.J. (2012), *Science, Technology, Engineering, and Mathematics (STEM) Education: A primer*, Congressional Research Service Report for Congress, available at: https://fas.org/sgp/crs/misc/R42642.pdf

[103] We have replicated the descriptive and econometric analysis for a more traditional definition of STEM, i.e., including the ICT sectors. Results are overall similar to those for STEM without ICT and can be reviewed in the Annex to this report.

- **ICT-career group**: dummy variable equal to 1 if students indicate that their future job will be an information and communications technology (ICT) profession, corresponding to ISCO sub-major group 25 and information and communication technicians (ISCO codes 3500 to 3522).
- **Healthcare-career group**: dummy variable equal to 1 if students indicate that their future job will be a health or health associate professionals: ISCO codes 2200 to 2269 (health professionals) and ISCO codes 210 to 3213 (health high-level technicians).

In the following sections we present a detailed descriptive analysis of the main variables of interest, for each of the above career-aspiration groups. In the econometric analysis, we will not investigate the determinants of the gender gap in healthcare career aspirations in further detail, as this is outside the scope of the present study.

We start with the description of the gender differences in STEM/ICT/healthcare in EU27 Member States and the UK. We then describe how the PISA 2018 proxies for the main theoretical drivers of career aspirations change for boys and girls in the same career-aspiration groups and for girls with different career aspirations. The Box below provides a summary of the results of this analysis.

Box 7.1: Summary of descriptive results

- Career aspirations in STEM/ICT and healthcare sectors are not evenly distributed across sexes. While boys show a preference for STEM/ICT professions more often than girls, more girls than boys aspire to healthcare professions.
- When comparing gender differences in career aspirations in STEM and ICT, there are considerable variations across countries. A few countries with a large gap in ICT have a small gap in STEM aspirations and vice versa (e.g., Austria, Bulgaria, Estonia, Ireland, Lithuania, Portugal, Poland, Romania).
- It is not possible to detect any clear regional pattern in the distribution of gender gaps. The exception is the small gender differences in career aspirations in STEM which are predominantly in eastern European countries while many of these countries have large gender differences in ICT.
- OECD PISA 2018 data contain variables that proxy some of the theoretical drivers of STEM career aspirations. For each factor, we present:
  a) Differences between girls and boys in the same career aspiration group
  b) Difference between girls in different career aspiration groups.

The results of the descriptive analysis are summarised in Table 2, which connects the theoretical drivers of career aspirations based on the SCCT to the PISA 2018 variables.

Table 2. Summary of descriptive findings in relation to the conceptual framework

SCCT factor	PISA 2018 proxy	Descriptive results
STEM learning experiences	How students obtain information about occupation and education opportunities	Boys, more often than girls, report being exposed to job-shadowing, career fairs and career counselling. Girls are more likely to obtain information on education or professional opportunities online

School performance in STEM subjects as an outcome of STEM learning experiences	PISA competences in science and mathematics	Girls who aspire to STEM and ICT professions are higher performers in terms of science competences: they perform better than girls with other career aspirations and better than boys with similar career aspirations. Girls who aspire to healthcare professions perform worse in terms of science competences than boys with similar career aspirations.
STEM interest and motivation	• Competitiveness • Motivation to master goals and tasks • Self-efficacy • Fear of failure • Value of school	Girls who aspire to STEM professions value school more and are more motivated to achieve their tasks than boys in the same career group. No differences of note are found for the other variables and career groups, both within and between genders.
Family factors: social and economic status, presence of role models in the family	• Economic, Socio-Cultural Status (ESCS) • Parents in STEM • Parental emotional support • Migration background	All family factors appear to be positively associated with both boys' and girls' aspirations to ICT and STEM professions. There is weak evidence that parental emotional support is a stronger driver of girls' rather than boys' aspirations and no relevant gender difference is found, at the descriptive level, between the association of STEM parents with STEM career aspirations.
Peer factors: peer-choices and support of the group of peers	• Peer competition • Peer cooperation • Sense of belonging	Girls who aspire to STEM or ICT professions report a lower sense of belonging than other 15 years old girls and boys in the same career-aspiration group. Differences both between and within genders are not very large.

5.2 Differences in STEM, ICT and Healthcare career aspirations: an overview for EU27 countries and the UK

Table 3 presents the extent of the gender differences in STEM, ICT and healthcare career aspirations, computed using OECD PISA 2018. The difference is the percentage of girls minus the percentage of boys indicating that they expect to be in a STEM, ICT or health profession when they are 30 years old. The differences are expressed in percentage points (pp). A negative difference indicates that the proportion of boys with career aspirations in STEM/ICT/Healthcare is higher than the proportion of girls, while a positive difference indicates that the proportion of girls with career aspirations in STEM/ICT/Healthcare is higher than the proportion of boys.

As we can see from Table 3, the average gender difference in STEM and ICT career aspirations is negative and statistically significant. The difference in ICT career aspirations in the EU27 is slightly higher (8.9) than that in STEM (8.1), although the differences in STEM are more dispersed than those in ICT[104]. The average gender difference in healthcare career aspiration is positive and significant. When compared to the magnitude of the STEM and ICT gender gaps, the average gender difference in healthcare career aspirations in the EU27 is much higher, 13.6 percentage points.

The EU27 figures are confirmed also at the country level. The differences in STEM career aspirations are negative and statistically significant in all countries except Bulgaria (where the difference is negative but not statistically significant). The largest differences are found in Slovenia (- 20 pp), Portugal (- 15.4 pp) and Austria (- 14.4 pp).

Turning to career aspirations in ICT, a different picture emerges. As with STEM, the differences in career aspiration in ICT are negative and statistically significant in all countries. Moreover, gender differences in ICT aspirations seem to follow a reverse pattern with respect to STEM career aspirations. For instance, Poland is one of the countries with the smallest gender gap in STEM career aspirations (2 pp) while it has the largest gap in terms of ICT aspirations (17.6 pp). Bulgaria, where the gap in STEM is the smallest (-1.1 pp) and not statistically significant has a -14.7 pp (and statistically significant) gender gap in ICT aspirations.

As to healthcare career aspirations, in line with what reported in other studies[105], we find a positive and statistically significant gender difference in career aspirations in the healthcare sector in all countries. In all EU Member States, the proportion of girls who expect to be health professionals at the age of 30 is between 8.1 (in Luxembourg) and 22.5 percentage points (in Finland) higher than among boys. The countries with the largest gaps are Finland (22.5 pp), Denmark (20.8 pp) and Ireland (18.4), while Malta (9.1 pp), Hungary (8.3 pp) and Luxembourg (8.1 pp) display the smallest gaps.

[104] The coefficient of variation is -53.6 for the gender gaps in STEM and -45.42 for the gender gaps in ICT.

[105] See https://www.oecd.org/gender/data/women-make-up-most-of-the-health-sector-workers-but-they-are-under-represented-in-high-skilled-jobs.htm

Table 3. Gender gap in career aspirations in STEM, ICT and Health professions

	Gender differences in career aspirations (% of girls - % of		
Countries	**STEM**	**ICT**	**Health**
AT	-14.4	-5.9	10.3
BE	-8.5	-7.4	13.9
BG	*-1.1*	-14.7	12.9
CZ	-6.1	-7.7	12.9
DE	-6.8	-5.8	9.1
DK	-8.1	-5.4	20.8
EL	-4.9	-7.1	10.3
ES	-8.7	-8.4	12.2
EE	-3.8	-16.8	12.4
FI	-4.4	-3.9	22.5
FR	-10.1	-6.2	11.0
HR	-10.2	-9.8	14.0
HU	-10.8	-11.6	8.3
IE	-11.7	-3.2	18.4
IT	-9.0	-6.7	9.3
LT	-3.8	-17.0	18.3
LU	-6.6	-7.1	8.1
LV	-8.3	-12.4	16.7
MT	-13.4	-7.0	9.1
NL	-5.3	-6.4	11.0
PL	-2.0	-17.6	17.4
PT	-15.4	-5.7	18.1
CY	-5.4	-8.8	14.3
RO	-4.0	-11.4	16.4
SK	-5.6	-6.7	13.0
SI	-20.0	-8.3	16.0
SE	-9.5	-5.7	13.5
UK	-9.7	-6.3	14.9
EU27	**-8.1**	**-8.7**	**13.7**

Source: *own computation based on OECD PISA data. The gap is computed as the difference between the percentage of girls and the percentage of boys who indicate that they see themselves as working in a STEM, ICT, or Health professional, when asked the question: "What kind of job do you expect to have when you are about 30 years old?", in the PISA 2018 student questionnaire. All estimates are statistically significant (p-value < 0.05), except for the gender differences in STEM aspirations in Bulgaria, which is indicated in italics.*

To further help cross-country comparisons, in Table 4 we have grouped countries based on the values of the observed gender differences in aspirations in STEM, ICT and healthcare. For each career aspiration types, we formed three groups:

- **A large-gap group**: countries belong to this group if the gender difference in career aspirations (in absolute value) is larger than the 3rd quartile of the cross-country distribution of gender gaps.
- **A medium-gap group**: countries belong to this group if their gender difference (in absolute value) is between the 1st (included) and 3rd quartile (included) of the cross-country distribution of gender gaps.
- **A small-gap group**: countries belong to this group if their gender difference (in absolute value) is below the 1st quartile of the cross-country distribution of gender gaps.

Based on the above classifications, and comparing the STEM and healthcare career aspirations, we can see that most countries classify as medium-gap countries. There are however some notable cases of countries that do not display a consistent classification in the different groups. For instance, we can observe:

- Countries with small differences in STEM and large gaps in healthcare career aspirations (Poland, Finland, Lithuania)
- Countries with large STEM gender differences and small healthcare gender differences (Austria, Hungary and Malta).

Similarly, if we compare STEM and ICT career aspirations, we can again observe that, while most countries are in the medium-gap group, there are:

- Countries with small differences in STEM and high level of gaps in ICT (Bulgaria, Estonia, Latvia, Poland, Romania)
- Countries with large gender differences in STEM and small differences in ICT career aspirations (Austria, Ireland, Portugal)

Based on this classification, it is not possible to detect any clear regional pattern in the distribution of gender gaps. The exception is the small gender differences in career aspirations in STEM which are predominantly in eastern European countries while many of these countries have large gender differences in ICT. Otherwise, the groups are made up of countries that are heterogeneous in terms of economic characteristics and educational systems. Hence, the gender gaps (in the three sectors considered) do not seem to be linked to country characteristics in an obvious way. Our econometric analysis will investigate this issue further (through the country-by-country econometric models) and will attempt to achieve a more refined country grouping (based on the regression coefficients rather than the raw gender gaps).

Table 4. Country grouping based on the level of the gender gap in STEM, ICT and healthcare career aspirations

Country grouping based on the gender gap in STEM, ICT, and healthcare career aspirations		
Gender differences in career aspirations in STEM		
Large (between -10pp and -20pp)	**Medium** (between -5pp and -10pp)	**Small** (lower than -5pp)
AT, IE, HU, HR, MT, PT, SI	BE, CY, CZ, DE, ES, DK, FR, IT, LU, LV, NL, SE, SK, UK	BG, EE, EL, FI, LT, PL, RO
Gender differences in career aspirations in ICT		
Large (between -11pp and -17 pp)	**Medium** (between -6pp and -11pp)	**Small** (lower than -6pp)
BG, EE, HU, LT, LV, PL, RO	BE, CY, CZ, EL, ES, FR, HR IT, LU, MT, NL, SK, SI, UK	AT, DK, DE, FI, IE, PT, SE
Gender differences in career aspirations in healthcare		
High (between 16.5pp and 22.5pp)	**Medium** (between 11pp and 16.5pp)	**Small** (lower than 11pp)
DK, IE, FI, LT, LV, PL, PT	BE, BG, CY, CZ, EE, ES, FR, HR, NL, RO, SE, SI, SK, UK	AT, DE, EL, HU, IT, LU, MT

Source: *Own elaborations based on OECD PISA 2018 microdata analysis. A country is classified as having a **large** gender difference in career aspirations if the difference in career aspirations between boys and girls in that country is above the 3rd quartile of the distribution of differences in career aspirations in the EU27 and the UK; a country is classified as having a **medium** difference if the difference in career aspirations between boys and girls in that country is between the 1st and 3rd quartile of the distribution of gender differences in the EU27 and the UK; a country is classified as having a **small** gender difference if its gender difference in career aspirations is below the 1st quartile of the distribution of gender differences in the EU27 and the UK.*

5.3 Cross country patterns in the main drivers of career aspirations

The objective of this section is to understand whether the gaps observed in the previous section reflect gaps in the theoretical drivers of career aspirations, as proxied in the OECD PISA 2018 questionnaire. We will present descriptive statistics for the following sets of variables:

- School performance (as measured by PISA competences)
- Factors that students report as important for the choice of their future occupation
- Motivation and self-efficacy factors
- Family and peer factors
- Access to information on employment and education opportunities

For each set of variables, we present both a comparison between boys and girls within the same career aspiration group and a comparison between girls with and without STEM/ICT/Healthcare career aspirations. In this way we aim to answer the following questions:

- How different are girls with career aspirations in STEM/ICT/Healthcare from boys with the same career aspirations?
- Who are the girls who choose different types of careers? How are girls who aspire to STEM/ICT/Healthcare professions different from other 15-year-old girls?

5.3.1 Gaps in school performance

Given the systematically lower proportion of girls with career aspirations in STEM than boys, it is natural to ask whether this pattern is driven by a systematically worse performance of girls in scientific subjects. The comparison of boys' and girls' PISA scores in mathematics and science helps shed light on this issue. PISA scores are standardised (to have a range between 324 and 597 in every country), so that the results are comparable across countries.

As reported in OECD (2019)[106], among the students who took the PISA 2018 test, girls' performance in mathematics was worse than boys in 12 out of 27 EU countries (Austria, Belgium, Croatia, Estonia, France, Germany, Hungary, Italy, Latvia, Luxembourg, Portugal, and Spain), while in the other 15 countries either the difference between boys' and girls' performance was not statistically significant or girls outperformed boys. Even in the countries where a statistically significant difference in mathematics was found, the size of the gap was not large (the largest gap between boys and girls was 13 points). As to the science scores, in no EU Member State did girls perform worse than boys, while in 12 EU Member States (Bulgaria, Cyprus, Estonia, Finland, Greece, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Slovenia, Sweden) girls had a better science performance than boys.

5.3.1.1 Gender differences

To further explore the possible association between gender gaps in STEM career aspirations and school performance, we computed differences by gender in each PISA competence within the three career aspiration groups of interest: i.e., STEM, ICT and healthcare. This analytical exercise answers the question: *"Do girls and boys who expect to have a career in STEM/ICT/Healthcare have similar school performances?".* Table 5 to Table 7 summarise the results. Alongside the average gap for the EU27, the tables report the countries for which statistically significant results were found. Countries that are not mentioned in the table are those where no significant difference (either in favour of boys or of girls) was found.

Across the three types of career aspirations considered, girls are found to outperform boys in reading competences in the EU27 as a whole and in most EU Member States and the UK.

Looking at maths and science performance, we can detect some gender differences across career aspirations. If we focus on students who expect to have a career in a STEM profession, we do not find large differences in science and mathematics performance between boys and girls. For science, girls outperform boys by 10 points on average in the EU27. The five countries where girls have the largest advantage in science over boys are Greece (34.8), Finland (49.2), Hungary (34.3) Malta (45.8) and Slovenia (33.6). Only in Belgium do boys who expect to be in a STEM profession perform better than girls in science (the gap is 23.9 in favour of boys). In the rest of the EU Member States and the UK, girls and boys do not have greatly different science

[106] OECD (2019), *PISA 2018 Results (Volume (II): Where all students can succeed*, Paris, OECD Publishing.

performance. In terms of PISA scores in mathematics, boys and girls with STEM career aspirations seem to perform similarly in most countries, which is different from the results for the overall sample reported by the OECD. Hence, if we focus on students with career aspirations in STEM, the advantage that boys seem to have in mathematics disappears almost completely.

Within the group of students with ICT career aspirations (Table 3), girls and boys perform similarly in terms of both science and maths competences. The only exceptions are France, Denmark (where boys outperform girls in mathematics in both countries) and Cyprus (where girls outperform boys in science).

Turning to the group of students who expect to work in the healthcare sector, we find more marked gender differences in mathematics and science performance. On average in the EU27 girls obtain a score that is 27 points lower than boys' score in mathematics and 17 points lower in science. Nowhere in the EU do girls who have career aspirations in healthcare professions outperform boys in mathematics and science competences.

Although the results are just descriptive and we should be cautious against overinterpreting them, they seem to suggest two main messages:

- **Girls who expect to be employed in STEM professions are top performers in mathematics and science**. This might be interpreted as evidence of barriers to entry in STEM professions: girls consider STEM professions very difficult to access, and hence only the top performers (who are as good as or even better than boys at science and maths) seem to be able to develop and take forward an interest in those professions.
- By contrast, **within the group of students with aspirations in healthcare professions boys outperform girls in mathematics and science**. This can be interpreted in two ways. Firstly, girls may regard healthcare professions as closer to them and more accessible and hence a girl who aspires to a job in the healthcare sector is closer to the "average" girl in OECD PISA. Secondly, there could well be gender segregation within the health professions, with girls aspiring (for several reasons) to more care-intensive health professions (e.g., nurses) and boys aspiring to more research or science-intensive health professions (e.g., biologists, health researchers or medical doctors). While disentangling this puzzle in the selection in health profession is out of the scope of this assignment, it could be an interesting topic for future research.

Table 5. Countries with statistically significant gender differences in PISA scores within the STEM career group

	Summary of country results		
PISA competence	**Countries where girls outperform boys [a]**	**Countries where boys outperform girls [a]**	**Average EU27 difference (score for girls minus score for boys) [b]**
Reading	AT, CY, CZ, DK, EE, EL, ES, FI, FR, HR, HU, IE, LT, LU, LV, MT, PL, RO, SE, SI, SK, UK	-	**36.9**

Mathematics	CY, EL, FI, HU, MT, SI	BE, IT, NL, PT	-0.3
Science	CY, EL, FI, HR, HU, IE, MT, NL, PT, SI, SK	BE	**10.1**

[a] This column shows the countries where a statistically significant difference (p-value < 0.05) between girls' and boys' performance was found.

*[b] Average difference within EU27 countries. Differences that are statistically significant (p-value < 0.05) are in **bold**.*

***Source:** Own computations based on OECD PISA microdata.*

Table 6. Countries with statistically significant gender differences in PISA scores within the ICT-career group

	Summary of country results		
PISA competence	**Countries where girls outperform boys [a]**	**Countries where boys outperform girls [a]**	**Average EU27 difference (score for girls minus score for boys) [b]**
Reading	BG, CY, EE, ES, HR, LT, MT, NL, PL, RO, SI	-	**29.4**
Mathematics		FR	-5.4
Science	CY	DK	6.0

[a] The column shows the countries where a statistically significant difference (p-value < 0.05) between girls' and boys' performance was found.

*[b] Average difference within EU27 countries. Differences that are statistically significant (p-value < 0.05) are in **bold**.*

***Source:** Own computations based on OECD PISA microdata.*

Table 7. Countries with statistically significant gender differences in PISA scores within the health-career group

	Summary of country results		
PISA competence	**Countries where girls outperform boys [a]**	**Countries where boys outperform girls [a]**	**Average EU27 difference (score for girls minus score for boys) [b]**
Reading	DE, EL, HR, LU, NL	-	**7.7**
Mathematics	-	AT, BG, CY, DK, EE, EL, ES, FI,	**-25.2**

		FR, HR, HU, IE, IT, LT, LV, MT, PL, PT, RO, SI, UK	
Science	-	AT, BG, CY, DK, EE, ES, FI, FR, HU, IE, PL, PT, RO, UK	**-17.2**

[a] The column shows the countries where a statistically significant difference (p-value < 0.05) between girls' and boys' performance was found.

*[b] Average difference within EU27 countries. Differences that are statistically significant (p-value < 0.05) are in **bold**.*

***Source:** Own computations based on OECD PISA microdata.*

5.3.1.2 Differences between girls with different career aspirations

The results described in the previous section focused on the differences between boys and girls within the same career-aspiration group. We are also interested in understanding whether girls who have career aspirations in the three sectors under study are different from those girls who do not aspire to a job in those sectors.

Table 8 to 0 summarise these comparisons. On average for the EU27, girls who report career aspirations in STEM, ICT and the healthcare sector outperform other girls in all PISA competences. We notice an especially large gap in mathematics and science performance between girls with STEM and ICT aspirations with respect to girls who do not have those career aspirations. Average gaps are slightly lower when comparing girls with and without career aspirations in the healthcare sector. Country-level differences are all statistically significant and positive for the three career-aspiration groups, denoting an advantage of girls with aspirations in STEM/ICT/healthcare with respect to other girls.

Combined with the results discussed in the previous sub-section, the analysis of school performance tells us that girls who aspire to a career in STEM/ICT/Healthcare sectors perform better than the other girls in all PISA competences, but:

- Girls with career aspirations in STEM and ICT appear to perform better than other girls with different career aspirations and to have a similar (and in some cases better) school performance in mathematics and science than boys within the same career aspiration group.
- Girls with career aspirations in the healthcare sector perform better than other girls with different career aspirations but not better (and in some cases worse) than boys within the same career aspiration group, especially in mathematics and science.

Table 8. Countries with statistically significant differences in PISA scores between girls in the STEM-career group and others

	Summary of country results		
PISA competence	**Countries where girls in the STEM-career group outperform the others [a]**	**Countries where girls in the STEM-career group underperform the others [a]**	**Average EU 27 difference** **(score for girls in the STEM-career group minus score for other girls) [b]**

Reading	All EU27 countries and the UK	-	**43.2**
Mathematics	All EU27 countries and the UK	-	**45.8**
Science	All EU27 countries and the UK	-	**46.4**

[a] The column shows the countries where a statistically significant difference (p-value < 0.05) between girls with STEM career aspirations and girls with all other career aspirations was found.

*[b] Average difference in EU27 countries. Statistically significant differences (p-value < 0.05) are in **bold**.*

***Source:** Own computations based on OECD PISA microdata.*

Table 9. Countries with statistically significant differences in the scores between girls in the ICT-career group and others

	Summary of country results		
PISA competence	**Countries where girls in the ICT-career group outperform the others [a]**	**Countries where girls in the ICT-career group underperform the others [a]**	**Average EU27 difference (score for girls in the ICT-career group minus score for other girls) [b]**
Reading	BG, CY, CZ, HR, HU, LT, MT, NL, PL, RO, SI, SK	-	**40.9**
Mathematics	BG, CY, CZ, HR, HU, LT, LV, MT, NL, PL, RO, SK, UK	-	**39.7**
Science	BG, CY, CZ, EE, EL, ES, HR, HU, IE, LT, LU, LV, MT, NL, PL, RO, SK, UK	-	**46.6**

[a] The column shows the countries where a statistically significant difference (p-value < 0.05) between girls with ICT career aspirations and girls with all other career aspirations was found.

*[b] Average difference in the EU27 countries. Statistically significant differences (p-value < 0.05) are in **bold**.*

***Source:** Own computations based on OECD PISA microdata.*

Table 10. Countries with statistically significant differences in PISA scores between girls in the health-career group and others

	Summary of country results		
PISA competence	**Countries where girls in the healthcare-career group outperform the others [a]**	**Countries where girls in the healthcare career group underperform the others [a]**	**Average EU27 difference (score for girls in the healthcare-career group minus score for other girls)[b]**
Reading	All countries except DK, SE, UK	-	**30.0**
Mathematics	All EU27 countries and the UK, except for DK and SE	-	**31.3**
Science	All countries except for DK, SE, UK	-	**31.6**

[a] *The column shows the countries where a statistically significant difference (p-value < 0.05) between girls with career aspirations in the healthcare sector and girls with all other career aspirations was found.*

[b] *Average difference in EU27 countries. Statistically significant differences (p-value < 0.05) are in **bold**.*

Source: *Own computations based on OECD PISA microdata*

5.3.2 Self-reported factors that are important for career choice

What are the factors that students consider important for the choice of their future occupation? PISA 2018 allows analysing this issue through a question contained in the in the educational career questionnaire. As the educational career questionnaire is not mandatory, results are only available for fewer EU27 Member States: Austria, Belgium, Bulgaria, Denmark, Spain, United Kingdom, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia.

Given limited country availability, we will report and comment here only on aggregate results (e.g., averages based on the available countries). Country-level results are available in the annex to this report.

As we did for the previous set of descriptive statistics, we present gender differences within career-aspiration groups and differences across career aspirations. Results are presented in Table 11 to Table 16.

5.3.2.1 Gender differences

In general, the differences in the factors that students consider important for their career choice do not seem to differ markedly between boys and girls. While there are some statistically significant differences in the proportion of boys and girls mentioning each factor, the magnitude of these differences is not very large. Across the three career-aspiration groups, boys seem to value slightly more their parents' expectations than girls and the plans that their close friends have. Girls seem to base the choice of the future occupation more on their school performance (grades and school subjects they are good at) and potential employment opportunities in the future occupations.

This is particularly evident among girls with STEM and ICT career aspirations. Boys with STEM career aspirations seem to value more the social status of the future profession than girls, and boys with career aspirations in the healthcare sector seem to value more the expected salary.

Some of these results can be interpreted in the light of the findings on school performance presented in Section 5.3.1. The higher value girls in the STEM- and ICT-career groups place on their school performance matches the previous finding that girls in these groups are top performers in maths and science (and sometimes outperform boys in the same career aspirations groups in these subjects). These links are less evident for girls in the healthcare-career group. In fact, we previously saw that within the healthcare career group, boys outperform girls in maths and science, so it is not surprising to find that school performance is considered of lower importance for girls in this career-aspiration group. The finding that girls with STEM career aspirations value the choices of their close friends less than boys may reflect the fact that girls who are determined to pursue a career in professions where women are less represented, are more independent of the pressure of their peer-group.

Table 11. Differences in the proportion of girls and boys with STEM career aspirations mentioning factors that are important for the choice of future occupation (statistically significant differences are in bold).

How important are the following things in the decisions you make about future occupations?	Average gender gap (proportion of girls mentioning each factor minus proportion of boys mentioning each factor)	Countries with the largest statistically significant gender gap (value of the gap in parenthesis)[1]
My parents' or guardians' expectations about my occupation	**-0.05**	MT (-0.18), SK (-0.14), HU (-0.12)
The plans my close friends have for their future	**-0.11**	EL (-0.17), MT (-0.26), SK (0.16)
My school grades	**0.07**	HU (0.11), LT (0.21), SI (0.19)
The school subjects I am good at	**0.06**	SI (0.17), LT (0.13), EL (0.09)
My special talents	**0.04**	HU (0.10), PL (0.10), SI (0.09)
My hobbies	0.02	-
The social status of the occupation I want	**-0.06**	IE (-0.13), MT (-0.16), UK (-0.13)
Financial support for education or training	0.02	-

How important are the following things in the decisions you make about future occupations?	Average gender gap (proportion of girls mentioning each factor minus proportion of boys mentioning each factor)	Countries with the largest statistically significant gender gap (value of the gap in parenthesis)[1]
Education or training options for the occupation I want	**0.07**	HU (0.12), PL (0.12), SI (0.18)
Employment opportunities for the occupation I want	**0.06**	EL (0.11), PL (0.12), SI (0.15)
The expected salary for the occupation I want	0.00	BE (-0.06) MT (-0.07), UK (-0.11)

[1]The value of the gender difference is in parenthesis. The reported countries are those for which a significant (p-value < 0.05) gender difference was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls reporting that that specific factor is important for the choice of their career is higher than the percentage of boys reporting the same factor. Vice-versa, a negative value of the difference means that on average the percentage of boys reporting that that specific factor is important for the choice of their career is higher than the percentage of girls reporting the same factor.*

Table 12. Difference in the proportion of girls and boys within the ICT-career group mentioning factors that are important for the choice of future occupation (statistically significant differences are in bold).

How important are the following things in the decisions you make about future occupations?	Average gender gap (proportion of girls mentioning each factor minus proportion of boys mentioning each factor)	Countries with the largest statistically significant gender gap (value of the gap in parenthesis)[1]
My parents’ or guardians’ expectations about my occupation	-0.03	EL (-0.35), MT (-0.20), SK (-0.16)
The plans my close friends have for their future	-0.06	MT (-0.30), SI (-0.27), UK (-0.27)
My school grades	**0.06**	HU (0.20), IT (0.26), PL (0.22)
The school subjects I am good at	**0.05**	DK (0.19) IT (0.27) LT (0.15)
My special talents	0.00	-

My hobbies	**-0.08**	AT (-0.25), HR (-0.32), SI (-0.49)
The social status of the occupation I want	-0.04	HU (-0.20), IE (-0.29), MT (-0.19)
Financial support for education or training	**0.08**	BE (0.48), DK (0.36)
Education or training options for the occupation I want	**0.08**	BE (0.43), DK (0.30), PL (0.16)
Employment opportunities for the occupation I want	**0.09**	BE (0.37) DK (0.23) EL (0.23)
The expected salary for the occupation I want	0.03	BE (0.37), IT (0.21)

[1]The value of the gender difference is in parenthesis. The reported countries are those for which a significant (p-value lower than 0.05) gender gap was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls reporting that that specific factor is important for the choice of their career is higher than the percentage of boys reporting the same factor. Vice-versa, a negative value of the difference means that on average the percentage of boys reporting that that specific factor is important for the choice of their career is higher than the percentage of girls reporting the same factor.*

Table 13. Differences in the proportions of girls and boys within the healthcare career group mentioning factors that are important for the choice of future occupation (statistically significant differences are in bold).

How important are the following things in the decisions you make about future occupations?	Average gender gap (proportion of girls mentioning each factor minus proportion of boys mentioning each factor)	Countries with the largest statistically significant gender gap (value of the gap in parenthesis)[1]
My parents' or guardians' expectations about my occupation	**-0.06**	BE (-0.19), EL (-0.18), MT (-0.17)
The plans my close friends have for their future	**-0.07**	ES (-0.13), MT (-0.25), SK (-0.13)
My school grades	**0.03**	BE (0.10), ES (0.04),
The school subjects I am good at	**0.02**	BE (0.11)
My special talents	0.00	-

My hobbies	0.00	UK (-0.10)
The social status of the occupation I want	-0.04	DK (-0.20), MT (-0.13), UK (-0.13)
Financial support for education or training	0.02	-
Education or training options for the occupation I want	**0.04**	BE (0.15), HR (0.07), SI (0.10)
Employment opportunities for the occupation I want	**0.02**	PL (0.13)
The expected salary for the occupation I want	**-0.04**	AT (-0.08), HU (-0.09), IT (-0.11)

[1]The value of the gender gap is in parenthesis. The reported countries are those for which a significant (p-value lower than 0.05) gender difference was found. Up to three countries are reported.

Source*: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in* ***bold.*** *A positive value of the difference means that on average the percentage of girls reporting that that specific factor is important for the choice of their career is higher than the percentage of boys reporting the same factor. Vice-versa, a negative value of the difference means that on average the percentage of boys reporting that that specific factor is important for the choice of their career is higher than the percentage of girls reporting the same factor.*

5.3.2.2 Differences between girls with different career aspirations

Differences are not very marked between girls with or without career aspirations in the three sectors of interest. The patterns that emerge from the descriptive results are as follows:

- Girls with STEM, ICT and healthcare career aspirations tend to mention more often than other girls that they value employment opportunities, future salary, and training opportunities for the choice of their future occupation. This might reflect better information on the labour market for the professions they aspire to. It may also reflect the higher level of ambition of this group of girls, who are a more homogeneous group of girls being compared with a more heterogeneous group of all other girls.
- Similarly to what we saw earlier when comparing boys and girls, girls with STEM and healthcare career aspirations give more importance than other girls to their school performance (i.e. their school grades and the school subjects they are good at). Again, this finding seems to match the one that girls who choose these types of careers display in general better performances in PISA competences than other girls.
- Compared to other 15-years old girls, those who aspire to STEM careers seem to give less importance to the choices their friends make or to the social status of their future occupation. In addition, they give more importance to their talents and their hobbies. As we saw when discussing the gender gaps, the results on the choices of close friends may reflect a higher level of independence from peer pressure. Related to that, this piece of evidence may be a sign of higher self-efficacy: girls who develop career aspirations in subjects that are felt as “unusual” among their group of peers need to be more

motivated and less influenced by the choice of others than the typical 15-year-old student. In addition, the lower importance given to social status may indicate that girls who choose a STEM career are more driven by their passions rather than the social prestige they can achieve through a particular occupation.

- Girls with aspirations in the healthcare sector seem to pay more attention than others at the financial support they may obtain for their education. This probably reflects awareness of how expensive educational careers in the medical sector are.

Table 14. Differences in the proportions of girls with and without STEM career aspirations mentioning factors that are important for the choice of future occupation (statistically significant differences are in bold)

How important are the following things in the decisions you make about future occupations?	Difference (proportion of girls in the STEM-career group mentioning each factor minus proportion of other girls mentioning each factor), average	Countries with the largest statistically significant difference (value of the gap in parenthesis)1
My parents' or guardians' expectations about my occupation	0.0	EL (-0.07), LT (0.13), UK (-0.09)
The plans my close friends have for their future	**-0.03**	EL (-0.08), IT (0.11), MT (-0.14)
My school grades	**0.05**	HR (0.06), LT (0.13), SI (0.08)
The school subjects I am good at	**0.07**	DK (0.09), PL (0.09), SI (0.10)
My special talents	**0.05**	DK (0.08), LT (0.08), PL (0.10)
My hobbies	**0.03**	EL (0.05)
The social status of the occupation I want	**-0.05**	IE (-0.13), MT (-0.15), UK (-0.11)
Financial support for education or training	0.01	-
Education or training options for the occupation I want	**0.05**	HR (0.07), HU (0.10), PL (0.09)
Employment opportunities for the occupation I want	**0.05**	IE (0.08), IT (0.08), PL / SI (0.07)

How important are the following things in the decisions you make about future occupations?	Difference (proportion of girls in the STEM-career group mentioning each factor minus proportion of other girls mentioning each factor), average	Countries with the largest statistically significant difference (value of the gap in parenthesis)1
The expected salary for the occupation I want	**0.02**	HU (0.07) LT (0.09) PL (0.08)

[1]The value of the difference is in parenthesis. The reported countries are those for which a significant (p-value < 0.05) difference was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average difference is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls with STEM career aspirations reporting that that specific factor is important for the choice of their career is higher than the percentage of girls without STEM career aspirations reporting the same factor. Vice-versa, a negative value of the difference means that on average the percentage of girls without STEM career aspirations reporting that a specific factor is important for the choice of their career is higher than the percentage of girls with STEM career aspirations reporting the same factor.*

Table 15. Difference in the proportions of girls with and without ICT career aspirations mentioning factors that are important for the choice of future occupation between girls with and without ICT career aspirations (statistically significant differences are in bold)

How important are the following things in the decisions you make about future occupations?	Difference (proportion of girls in the ICT career group mentioning each factor minus proportion of other girls mentioning each factor), average	Countries with the largest statistically significant difference (value of the difference in parenthesis)[1]
My parents' or guardians' expectations about my occupation	-0.02	EL (-0.23), MT (-0.18)
The plans my close friends have for their future	0.03	DK (0.70), SI (-0.22), MT (-0.19)
My school grades	0.01	HU (0.18), IT (0.30), PL (0.18)
The school subjects I am good at	0.04	DK (0.15), EL (-0.18), IT (0.26)

How important are the following things in the decisions you make about future occupations?	Difference (proportion of girls in the ICT career group mentioning each factor minus proportion of other girls mentioning each factor), average	Countries with the largest statistically significant difference (value of the difference in parenthesis)[1]
My special talents	0.02	BE (0.29), DK (0.11), EL (0.10)
My hobbies	0.0	IT (0.19), PL (0.13), SI (-0.43)
The social status of the occupation I want	-0.05	HR (-0.17)
Financial support for education or training	0.04	BE (0.42), DK (0.38)
Education or training options for the occupation I want	**0.05**	BE (0.27), DK (0.20), PL (0.20)
Employment opportunities for the occupation I want	**0.08**	BE (0.30), DK (0.19), EL (0.16)
The expected salary for the occupation I want	**0.07**	BE (0.33), IE (0.31), SK (0.13)

[1]The value of the difference is in parenthesis. The reported countries are those for which a significant (p-value < 0.05) gap was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average difference is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls with ICT career aspirations reporting that that specific factor is important for the choice of their career is higher than the percentage of girls without ICT career aspirations reporting the same factor. Vice-versa, a negative value of the difference means that on average the percentage of girls without ICT career aspirations reporting that that specific factor is important for the choice of their career is higher than the percentage of girls with ICT career aspirations reporting the same factor.*

Table 16. Difference in the proportion of girls with and without healthcare career aspirations mentioning factors that are important for the choice of future occupation (statistically significant differences are in bold).

How important are the following things in the decisions you make about future occupations?	Difference (proportion of girls in the healthcare career aspiration group mentioning each factor minus proportion of other girls mentioning each factor), average	Countries with the largest statistically significant difference value of the difference in parenthesis)[1]
My parents' or guardians' expectations about my occupation	**0.02**	AT (-0.07), DK (0.10), IE / SK (0.06)
The plans my close friends have for their future	-0.03	AT (-0.12), IT (-0.08)
My school grades	**0.07**	BE (0.08), BG (0.10), DK (0.10)
The school subjects I am good at	**0.07**	LT (0.13), SI (0.12), SK (0.11)
My special talents	0.01	LT (0.09), SK (0.06), UK (-0.09)
My hobbies	**-0.02**	LT (0.09), BE/DK (-0.08), LT (0.09)
The social status of the occupation I want	0.007	BG (0.07)
Financial support for education or training	**0.04**	SK (0.07)
Education or training options for the occupation I want	**0.05**	BG (0.05), SI (0.08), SK (0.08)
Employment opportunities for the occupation I want	**0.04**	AT (0.08), SI (0.08), SK (0.08)
The expected salary for the occupation I want	**0.02**	HR (0.06), LT (0.08), SK (0.07)

[1]The value of the difference is in parenthesis. The reported countries are those for which a significant (p-value < 0.05) difference was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls with healthcare career aspirations reporting that that specific factor* *is important for the choice of their career is higher than the percentage of girls without healthcare career aspirations reporting the same factor. Vice-versa, a negative value of the difference means that on average the percentage of girls without healthcare career aspirations reporting that that specific factor is important for the choice of their career is higher than the percentage of girls with healthcare career aspirations reporting the same factor.*

5.3.3 Self-efficacy and motivation

As explained in our conceptual framework and in the literature reviewed at the beginning of this report, motivational factors play an important role for adolescents' career choices in general, and especially for the development of STEM career aspirations. The microdata from PISA 2018 contains several variables that proxy motivational factors. These are composite indexes, that the OECD constructs from a combination of different underlying variables. The indexes are standardised to have a mean of 0 and a standard deviation of 1. This standardisation means the indexes are comparable across countries. Below we present descriptive statistics on the following indexed variables:

- **Attitude towards competition**: Positive values on this scale mean that students expressed more favourable attitudes towards competition than did the average student across OECD countries.
- **Fear of failure**: Positive values in this index mean that the student expressed a greater fear of failure than did the average student across OECD countries.
- **Learning goals:** Positive values in the index indicate more ambitious learning goals than the average student across OECD countries.
- **Motivation to master tasks**: Positive values in the index indicate greater motivation than the average student across OECD countries.
- **Self-efficacy**: Positive values in this index mean that the student reported higher self-efficacy than did the average student across OECD countries.
- **Value of school**: Positive values on this scale mean that the student valued schooling to a greater extent than the average student across OECD countries.

The analysis aims to shed light on whether gender gaps in career aspirations are associated with gender gaps in students' motivation and self-confidence. Moreover, as we have done for the previous analysis, we explore the differences in the motivational factors between the group of girls with and without career aspirations in the sectors of interest. In this way we aim to understand in what respect girls with our featured career aspirations are different from all other girls in the same group of countries.

5.3.3.1 Gender differences

Tables 8 to 10 summarise the results on the gender gaps in self-efficacy and motivational factors. The first thing we notice is that across the three groups of students with different career aspirations, boys are always found to have a higher level of competitiveness than girls. Some of the psychological education literature has found that girls tend to be in general less competitive than boys and that the lack of competitive attitude may penalise girls in STEM exams. Our descriptive finding confirms that this gap in competitiveness does not disappear even within the group of students who have already developed STEM career aspirations.

Regarding **fear of failure**, in all EU27 countries and across career aspirations, girls are found to have a higher fear of failure than boys (except for a couple of countries where no significant differences between boys and girls was found). This result is particularly strong within the STEM and healthcare career groups. This finding can be interpreted considering the "stereotype threat" hypothesis, mentioned in the discussion of the relevant literature. Perhaps girls who would like to embark in difficult study or occupational careers (e.g., STEM) know that they will be working and studying in male-dominated sectors, and they might develop fear and anxiety to fail and to confirm (with their failure) the stereotype that girls are less good in scientific subjects.[107]

In terms of **self-efficacy**, the evidence suggests that girls in the STEM and healthcare career aspiration groups have lower self-efficacy than boys with similar career aspirations. Within the STEM-career group, differences are not very large (0.05 on average for the EU27). At the country level, the higher self-efficacy index for boys in the STEM-career group is statistically significant only for five countries. Within the healthcare-career group, the average gap in self-efficacy (in favour of boys) is higher (0.16), but statistically significant only in six countries.

The indexes on **the motivation to master tasks and learning goals** show that girls within each career-aspiration group are on average (in the EU27) more motivated to achieve their goals and to learn than boys. At the country-level, within the STEM-career group, girls are more motivated to master tasks than boys in 12 out of 28 countries. In the other countries, there are no differences between boys and girls in their motivation to master tasks index. Similarly, for the learning goals, while girls within the STEM-career group seem more motivated than boys in the same group, they are in general not too different from boys in the other career-aspirations groups. We saw earlier that girls in the STEM-career group give more importance to school performance when choosing their future profession. This result is mirrored in the **value of school** index, where we find that girls within the STEM-career group value school more than boys. Gender differences in the value of this index are not that large in the other two career-aspiration groups.

To summarise, the results of this section show that girls with career aspirations in STEM have only slightly lower levels of self-efficacy, are more motivated to achieve their tasks and place higher value on schooling than boys with the same career aspirations. These findings match some of the results discussed earlier. We have shown that girls in the STEM-career group perform very well in terms of PISA competences: perhaps being top performers boosts girls' confidence in their STEM abilities, and this is reflected in their higher motivation. We also saw earlier that girls in the STEM-career group are more likely to give importance to their school performance when deciding on their future occupation. This result matches the finding on the value of school index, which is larger for girls within the STEM-career group than for boys in the same group.

[107] Shapiro, J., Williams, A. (2012), *op. cit.*

Table 17. Countries with statistically significant gender differences in self-efficacy and motivational variables within the STEM-career group

Summary of country results			
Self-efficacy and motivation indexes as measured in PISA 2018	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference** **(value of the index for girls minus value of the index for boys)**
Attitudes towards competition	-	**All EU27 countries and the UK, except for** BG, EE, LT, MT, RO	**-0.25**
Fear of failure [a]	**All EU27 countries and the UK, except for BG**	-	**0.4**
Learning goals	CY, EL, ES, PL, PT, SK	-	**0.14**
Motivation to master tasks [a]	BG, CY, EL, ES, FR, IE, IT, LV, MT, PT, SI, SK	-	**0.18**
Self-efficacy [a]	BG	DK, IE, LU, PT, SE, UK	**-0.05**
Value of school	AT, CY, CZ, DE, EL, FI, IE, LV, NL, PT	-	**0.14**

[a] *Index not available for Belgium.*

Source: *Own computations based on OECD PISA microdata. For each motivation and self-efficacy index reported in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the index for girls and boys. The difference is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 18. Countries with statistically significant gender differences in self-efficacy and motivational variables within the ICT-career group

	Summary of country results		
Self-efficacy and motivation indexes as measured in PISA 2018	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference** **(value of the index for girls minus value of the index for boys)**
Attitudes towards competition	-	CY, NL	**-0.15**
Fear of failure [a]	EE, EL, FI, HR, HU, LU, LV, MT, NL, PL, RO, SI	-	**0.45**
Learning goals	ES, FR, MT, RO	BE, CZ	**0.15**
Motivation to master tasks [a]	EE, ES, FR, IT, LU, RO, SK	-	**0.17**
Self-efficacy [a]	-	FI, SI	-0.02
Value of school	MT, RO	BE, CZ	0.03

[a] *Index not available for Belgium*

Source: *Own computations based on OECD PISA microdata. For each motivation and self-efficacy index reported in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the index for girls and boys. The difference is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 19. Countries with statistically significant gender differences in the self-efficacy and motivational variables within the healthcare-career group

	Summary of country results		
Self-efficacy and motivation indexes as measured in PISA 2018	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference** **(value of the index for girls minus value of the index for boys)**
Attitudes towards competition	-	**All EU27 countries and the UK, except for** DK, LU, LV	**-0.34**
Fear of failure [a]	**All EU27 countries and the UK, except for** BG and SK	-	**0.39**
Learning goals	BE, ES, RO, SE	-	**0.05**
Motivation to master tasks [a]	DE, ES, LU, MT, SI	SE	**0.07**
Self-efficacy [a]	-	DK, ES, FR, IE, LU, PT, SE, SI, UK	**-0.16**
Value of school	-	IT, LT, UK	**0.02**

[a] *Index not available for Belgium.*

Source: *Own computations based on OECD PISA microdata. For each motivation and self-efficacy index reported in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the index for girls and boys. The difference is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in **bold**.*

5.3.3.2 Gaps between girls with different career aspirations

Are girls who choose STEM, ICT or healthcare careers more motivated and self-confident than others? This section answers this question, with results summarised in Table 20 to Table 22.

Looking at the three tables together, we can observe marked differences in the motivational factors between girls with STEM or healthcare career aspirations and other 15-year-old girls. Girls with STEM career aspirations outperform the others in particular in terms of learning goals and in terms of motivation to master tasks. On average in the EU27 the learning goal index is higher in the STEM-career group by 0.2. At the country-level, gaps in favour of the STEM-career group are found in 18 out of 28 countries. The motivation to master tasks is on average 0.13 higher for girls with STEM career aspirations than others, and the country-level results confirm this result in 10 countries.

Overall, these results are not surprising given what we know about the school performance of girls in the STEM-career group. One interpretation of these results is that the higher motivation of this group of girls might be the driving force behind both the better school performance they have and their career ambitions.

Differences in learning goals and motivation are even more marked between girls with and without aspirations in the healthcare sector.

Weaker evidence is found for the ICT-aspirations group. Girls within this group do not seem to be different from other girls in terms of self-efficacy and motivation, with the exception of a statistically significant difference in the value of school index, which however seems to be in favour of girls without ICT career aspirations.

Table 20. Countries with statistically significant differences in self-efficacy and motivational variables between girls with and without STEM career aspirations

	Summary of country results		
Self-efficacy and motivation indexes as measured in PISA 2018	**Index larger for girls in the STEM-career group**	**Index smaller for girls in the STEM career group**	**Average EU27 difference (value of the index for girls in the STEM-career group minus value of the index for other girls)**
Attitudes towards competition	CZ, HU, IE, LU	-	0.06
Fear of failure [a]	EL, LV	DK	0.02
Learning goals	BG, CY, CZ, EE, EL, ES, FI, FR, HU, IE, LT, LU, LV, PT, SE, SI, SK, UK	-	**0.2**
Motivation to master tasks [a]	BG, CY, EL, FR, HU, IE, LV, PT, SE, UK	-	**0.13**
Self-efficacy [a]	BG, CY, EE, ES, FI, FR, HU, IT	-	**0.08**
Value of school	BG, DE, EE, EL, LV, NL, PT, SE, SK	-	**0.1**

[a] *Index not available for Belgium.*

Source: *Own computations based on OECD PISA microdata. For each motivation and self-efficacy index reported in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the index for girls with and without STEM career aspirations. The difference is between the average index computed among girls with STEM career aspirations and the average index among girls without STEM career aspirations. The last column indicates the average difference in EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 21. Countries with statistically significant differences in self-efficacy and motivational variables between girls with and without ICT career aspirations.

Summary of country results			
Self-efficacy and motivation indexes as measured in PISA 2018	**Index larger for girls in the ICT-career group**	**Index smaller for girls in the ICT career group**	**Average EU27 difference (value of the index for girls in the ICT-career group – value of the index for other girls)**
Attitudes towards competition	BG, ES, PL, SK	CY	0.08
Fear of failure [a]	FI, LU, LV, RO, SI	ES, FR, IT,	0.06
Learning goals	FR,	BE, CZ, FI	-0.09
Motivation to master tasks [a]	FR, SK	SI	-0.02
Self-efficacy [a]	HU	FI, SI	0.0
Value of school	-	BE, FI, PT	**-0.2**

[a] *Index not available for Belgium.*

Source: *Own computations based on OECD PISA microdata. For each motivation and self-efficacy index reported in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the index for girls with and without ICT career aspirations. The difference is between the average index computed among girls with ICT career aspirations and the average index among girls without ICT career aspirations. The last column indicates the average difference in EU27 countries. In this column, are statistically significant differences (p-value < 0.05) are in* ***bold****.*

Table 22. Countries with statistically significant differences in self-efficacy and motivational variables between girls with and without career aspirations in the healthcare sector

	Summary of country results		
Self-efficacy and motivation indexes as measured in PISA 2018	**Index is larger for girls in the healthcare-career group**	**Index smaller for girls in the healthcare career group**	**Average EU27 difference** **(value of the index for girls in the healthcare career group minus value of the index for other girls)**
Attitudes towards competition	AT, BG, CZ, DE, FI, FR, HU, IE, LU, MT	-	**0.06**
Fear of failure [a]	BG, ES, FR, NL, PT	-	**0.05**
Learning goals	**All EU27 countries and the UK**	-	**0.05**
Motivation to master tasks [a]	**All EU27 countries and the UK**, except for: LT, LV, NL, RO	-	**0.3**
Self-efficacy [a]	AT, BG, CZ, DE, ES, FI, HU, LU, LV, MT, PL, SE, SK, UK	-	**0.11**
Value of school	**All EU27 countries and the UK**, except for: BE and RO	-	**0.2**

[a] *Index not available for Belgium.*

Source: *Own computations based on OECD PISA microdata. For each motivation and self-efficacy index reported in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the index for girls with and without STEM career aspirations. The difference is between the average index computed among girls with career aspirations in the healthcare sector and the average index among girls without career aspirations in the healthcare sector. The last column indicates the average difference among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in* ***bold****.*

5.3.4 Family factors

As we know from the literature and as suggested in our conceptual framework, family factors can be highly influential for the development of adolescents' career aspirations in several ways:

- First, the family is the main source of financial support for higher education, hence we expect that adolescents who aim at expensive educational careers, e.g., in the STEM or healthcare sectors, may come from wealthier families. We proxy overall family's socio-economic status with the **Economic, Social and Cultural Status (ESCS)** index in PISA 2018. The ESCS is a composite index derived by a set of variables proxying family's wealth and cultural status, e.g., parental education, parental wealth, educational resources at home (e.g., number of books).[108]
- Second, students with a migration background are often found to be disadvantaged when entering STEM or other prestigious occupations. The **migration background index in PISA 2018** measures whether the student is either foreign-born or is a second-generation migrant[109] and allows us to measure whether such disadvantage exists.
- Third, the family is the place where (besides the school) adolescents find their role models. In this descriptive analysis and later in the econometric models we will investigate whether having a **parent working in the STEM or healthcare sector** increases the probability that students report an interest in a career in the same sectors.
- Finally, the level of emotional support that parents give to their children can influence self-efficacy and motivation among students. As we saw previously when discussing the literature, it is important for girls to receive emotional support to study subjects that are not perceived as "usual" for girls. The level of emotional support received at home is proxied with the PISA 2018 **emotional support index,** measures the emotional support that children have from their parents.[110]

The analysis that follows investigates differences in the above family factors both within and between career-aspiration groups.

5.3.4.1 Gender differences

Table 23 to Table 25 report the results on the differences among boys and girls within the same career aspiration group. Gender differences in **parental socio-economic status** are not large among students with career aspirations in STEM. Among students with career aspirations in ICT and healthcare the gender gaps in socio-economic status go in opposite directions: while there is a slight tendency for girls in the ICT-career

[108] See https://www.oecd-ilibrary.org/sites/f7986824-en/index.html?itemId=/content/component/f7986824-en for details on the ESCS computations in the 2018 PISA.

[109] See https://www.oecd-ilibrary.org/sites/0a428b07-en/index.html?itemId=/content/component/0a428b07-en for details.

[110] The index of parental emotional support was constructed based on a question asking students whether they agree ("strongly disagree", "disagree", "agree", "strongly agree") with the following statements related to the academic year when they sat the PISA test: "My parents support my educational efforts and achievements"; "My parents support me when I am facing difficulties at school"; and "My parents encourage me to be confident". Positive values on this scale mean that students perceived greater levels of emotional support from their parents than did the average student across OECD countries. See https://www.oecd-ilibrary.org/sites/0a428b07-en/index.html?itemId=/content/component/0a428b07-en

group to come from families with a higher socio-economic status, boys in the health-aspiration group have a higher socio-economic status than girls in the same group.

Family emotional support seems to be associated more with girls' than boys' STEM career aspirations in 10 EU Member States. This result is in line with the literature, which points out how family support might be particularly important for girls' self-confidence and development of career aspirations. We do not find similar results for other career-aspiration groups.

Migration background does not significantly differ between boys and girls within each of the three career aspiration groups.

Regarding **parental occupation**, boys with career aspirations in the healthcare sector are found to have more often than girls at least one parent in the health profession. Such differences are not notable in the other career aspirations groups. Hence, except for the health profession, the descriptive evidence collected so far does not support the hypothesis that parental role models may influence boys and girls differently for their choice of a STEM career.

Table 23. Countries with statistically significant gender differences in family factors within the STEM-career group

	Summary of country results		
Family factor	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference (girls – boys)**
ESCS	HU, IE	-	**0.059**
Parents' emotional support	BG, CY, EL, ES, FR, HR, IE, IT, SE, SK	-	**0.173**
Migrant background	-	-	0.043
Parent in STEM	ES, HU	-	0.009
Parent in Health	CY	-	-0.0008

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant gap was found (p-value < 0.05) between the value of the variable for girls and boys. The gap is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 24. Countries with statistically significant gender differences in family factors within the ICT-career group

	Summary of country results		
Family factor	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference (value of the index for girls minus value of the index for boys)**
ECSE	BG, CZ, DE, FR, IT, LT, NL,	RO	**0.13**
Parents' emotional support	DK, RO	BE	-0.07
Migrant background	-	IT, PT, SI	0.02
Parent in STEM	-	DK, IT, PT	0.03
Parent in Health	-	BE, DK, IT, PT	0.02

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant gap was found (p-value < 0.05) between the value of the variable for girls and boys. The gap is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 25. Countries with statistically significant gender differences in family factors within the healthcare-career group

	Summary of country results		
Family factor	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference (value of the index for girls minus value of the index for boys)**
ECSE	-	BG, CY, CZ, EE, EL, ES, HU, IE, IT, LT, MT, PL, RO	**-0.16**
Parents' emotional support	CY, EE, ES, HR, IT, SI	FR	**0.09**
Migrant background	CY	SE	-0.01
Parent in STEM	DE, IE, SK	-	0.004

Parent in Health	-	BG, CY, EE, EL, FI, HR, IE, IT, SE	**-0.05**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant gap was found (p-value < 0.05) between the value of the variable for girls and boys. The gap is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

5.3.4.2 Gaps between girls with different career aspirations

When we compare girls with different career aspirations (Table 26 to Table 28), we notice a clear tendency for girls from families with higher socio-economic status to choose careers in the healthcare and STEM sectors. This confirms the hypothesis that family financial resources matter for the choice of expensive educational careers. Girls who choose a career in STEM or healthcare seem to also receive a higher level of parental emotional support, on average. This result is strongest in the healthcare career group. At the country-level, we find that in 22 countries girls in the healthcare-career group receive a higher (and statistically significant) level of emotional support than others, while for the STEM-career group this is true only for nine countries.

We also observe that **parental occupation** seems associated with the development of girls' careers aspirations. We see that girls with career aspirations in STEM more often report that one of their parents works in STEM. The results are even more marked for girls with career aspirations in the healthcare sector, who are much more likely than others to have a parent who works in the healthcare sector. This result is confirmed at the country level in 24 out of 28 countries.

The results for the ICT-career group are qualitatively similar to those found for the other groups. However, they are smaller in magnitude and less statistically significant. The only statistically significant differences between girls with and without ICT career aspirations are observed for the migration background index and for parental occupation. As to migration background, the results suggest that the proportion of girls with a migration background is higher within the ICT-career group than among the other 15-year-old girls. Regarding parental occupation, girls with ICT career aspirations seem to come more often from families where at least one parent works in the healthcare sector.

Table 26. Countries with statistically significant differences in family factors between girls with and without STEM career aspirations

	Summary of country results		
Family factor	**Index larger for girls within the STEM-career group**	**Index smaller for girls within the STEM-career group**	**Average EU27 difference** **(value of the index for girls in the STEM-career group minus value of the index for other girls)**
ECSE	**All EU27 countries** except for AT, BG, NL; **and UK**	-	**0.3**

Parents' emotional support	BG, CY, EL, ES, FR, HU, IT, PL, SK		**0.1**
Migrant background	-	BG, IT	0.005
Parent in STEM	BE, BG, CY, DE, DK, EL, ES, FI, FR, HR, HU, IE, IT, LT, LU, PT, SE, UK	-	**0.006**
Parent in Health	-	EL, LV	**-0.009**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the variable for girls with and without career aspirations in STEM. The difference is between the average index computed among girls with career aspirations in STEM and the average index among girls without career aspirations in STEM. The last column indicates the average difference among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 27. Countries with statistically significant differences in family factors between girls with and without ICT career aspirations

	Summary of country results		
Family factor	**Index larger for girls within the ICT-career group**	**Index smaller for girls within the ICT-career group**	**Average EU27 difference (value of the index for girls in the ICT-career group minus value of the index for other girls)**
ECSE	BG, CZ, DE, FR, HU, IT, LT, MT, NL, RO, SK	DK	**0.2**
Parents' emotional support	-	BE	0.05
Migrant background	-	BG, FI, IT, LT, PL, PT, SI, SK	**0.05**
Parent in STEM	DK, FR, HU	IT, PT	0.08
Parent in Health	-	BE, DE, DK, ES, FR, HU, IE, IT, LT, NL, PT, SE, SI	**-0.2**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the variable for girls with and without career aspirations in ICT. The difference is between the average index computed among girls with career aspirations in ICT and the average index among girls without career aspirations in ICT. The last column indicates the average difference among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 28. Countries with statistically significant differences in family factors between girls with and without healthcare career aspirations

	Summary of country results		
Family factor	**Index larger for girls within the healthcare-career group**	**Index smaller for girls within the healthcare-career group**	**Average EU27 difference** **(value of the index for girls in the healthcare-career group minus value of the index for other girls)**
ECSE	**All countries EU27 countries** except for DK, IE. Difference also not significant for the UK	-	**0.26**
Parents' emotional support	**All EU27 countries, except** for AT, BE, DE, IE, IT, LU. Difference not significant for the UK	-	**0.17**
Migrant background	DK, EE, FI, FR, HU, IE, NL, SE, UK		**0.02**
Parent in STEM	DE, EL, FR, HR, LU, SK	-	**0.02**
Parent in Healthcare	**All EU27 countries** except for EE, FI, PT. Difference not significant also for the UK	-	**0.06**

***Source:** Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the variable for girls with and without career aspirations in the healthcare sector. The difference is between the average index computed among girls with career aspirations in the healthcare sector and the average index among girls without career aspirations in the healthcare sector. The last column indicates the average difference among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in **bold**.*

5.3.5 Peer factors

The influence of peers is an important factor for the development of adolescents' career aspirations. The PISA 2018 questionnaire allows measuring the influence of peers in several ways. We have already seen above that the influence of close friends' decisions is one of the factors that students can mention when answering the question on their future career choices.

There are also other variables in PISA 2018 that proxy peer influence. We have examined the behaviour within and between career aspirations of the following indexed variables:

- **Student competition index**: Positive values in this index mean that students perceived that their peers compete with each other to a greater extent than did the average student across OECD countries.
- **Student cooperation index:** Positive values in this index mean that students perceived that their peers co-operate to a greater extent than did the average student across OECD countries.
- **Sense of belonging:** positive values on this scale mean that students reported a greater sense of belonging at school than did the average student across OECD countries.

The results for the gender gaps are summarised in Table 29 to Table 31, while the results for girls with and without career aspirations in the three sectors of interest are summarised in Table 32 to Table 34.

Overall, we do not notice great differences both between gender and career aspirations. Regarding the gender gaps, our results suggest boys within each career-aspiration group feel more peer competition and cooperation than girls. They also feel a greater sense of belonging to their group of peers than girls. The result on the difference in the sense of belonging might indicate, as we also noticed earlier, that girls who have career aspirations in STEM do feel that they are "different" from their group of peers, as they are interested in subjects and careers that are still considered "unusual" for girls.

Table 29. Countries with statistically significant gender differences in peer factors within the STEM-career group

	Summary of country results		
Peer factor	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference** **(value of the index for girls minus value of the index for boys)**
Peer competition	-	AT, CZ, ES, FI, NL, PT, SE, SI, SK	**-0.14**
Peer cooperation	DE	BE, PL, SE, SI, UK	0.02
Sense of belonging	CY	BE, CZ, DK, HR, IE, PL, PT, SE, UK	**-0.08**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant gap was found (p-value < 0.05) between the value of the variable for girls and boys. The gap is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 30. Countries with statistically significant gender differences in peer factors within the ICT-career group

	Summary of country results		
Peer factor	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference (girls – boys)**
Peer competition	-	BE, PT, RO, SE,	**-0.12**
Peer cooperation	DE	DK	0.05
Sense of belonging	IT	EE, EL, FI, LU, NL, SK	**-0.19**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant gap was found (p-value < 0.05) between the value of the variable for girls and boys. The gap is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 31. Countries with statistically significant gender differences in peer factors within the healthcare-career group

	Summary of country results		
Peer factor	**Index larger for girls than for boys**	**Index larger for boys than for girls**	**Average EU27 difference (girls – boys)**
Peer competition	-	AT, CZ, DK, FI, HR, HU, IE, LU, MT, PL, PT, SK, UK	**-0.16**
Peer cooperation	DE	BE, FI, FR, LU	**-0.08**
Sense of belonging	DE	DK, FI, FR, IE, MT, NL, SI, UK	**-0.1**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant gap was found (p-value < 0.05) between the value of the variable for girls and boys. The gap is measured as the difference between the average index computed among girls and the average index among boys. The last column indicates the average gap among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

If we compare the group of girls who aspire to different careers, the magnitude of the differences is smaller than the gender differences. The most notable results are once again for the healthcare-career group. Here we find that girls with career aspirations in the healthcare sector are more competitive and have a higher sense of belonging to their group of peers than girls with other career aspirations. In contrast, girls with STEM career aspirations perceive their peers in a more cooperative way compared to others.

In line with the above results by gender, we find that girls in the ICT career aspiration-group display a lower sense of belonging than other girls. Hence, girls who develop career aspirations in ICT feel more dissimilar to their group peers both with respect to boys and with respect to other girls.

Table 32. Countries with statistically significant differences in peer factors between girls with and without career aspirations in STEM

	Summary of country results		
Peer factor	**Index larger for girls within the STEM-career**	**Index smaller for girls within the STEM career group**	**Average EU27 difference (value of the index for girls in the STEM career group minus value of the index for other girls)**
Peer competition	BG, LT	-	-0.02
Peer cooperation	DE, ES, FR, HU, IE, LT, LU, SI, SK	-	**0.02**
Sense of belonging	SK	-	-0.02

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the variable for girls with and without STEM career aspirations. The difference is between the average index computed among girls with STEM career aspirations and the average index among girls without STEM career aspirations. The last column indicates the average index among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 33. Countries with statistically significant differences in peer factors between girls with and without career aspirations in ICT

	Summary of country results		
Peer factor	**Index larger for girls in the ICT-career group than for other girls**	**Index smaller for girls in the ICT career group than for other girls**	**Average EU27 difference (value of the index for girls in the ICT career group minus value of the index for other girls)**
Peer competition	BG, LT	-	0.05
Peer cooperation	DE, DK, HU	-	0.05
Sense of belonging	-	EE, EL, ES, FI, LU, NL, SE	**-0.2**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the variable for girls with and without ICT career aspirations. The difference is between the average index computed among girls with ICT career aspirations and the average index among girls without ICT career aspirations. The last column indicates the average difference among EU27 countries. In this column, gaps that are statistically significant (p-value < 0.05) are in* ***bold****.*

Table 34. Countries with statistically significant differences in peer factors between girls with and without career aspirations in the healthcare sector

	Summary of country results		
Peer factor	**Index larger for girls in the healthcare-career group**	**Index smaller for girls in the healthcare career group**	**Average EU27 difference (value of the index for girls in the healthcare career group minus value of the index for other girls)**
Peer competition	CY, EE, HU, IT, MT	CZ	**0.04**
Peer cooperation	CY, CZ, DE, DK, EE, ES, HR, HU, LV, NL, PL, PT, SE, SI, SK	-	0.01
Sense of belonging	BG, CY, CZ, DE, ES, FI, HR, HU, LT, LV, PL, PT, SK, UK	-	**0.01**

Source: *Own computations based on OECD PISA microdata. For each family factor in the PISA microdata (reported in the rows), the table shows the countries for which a statistically significant difference was found (p-value < 0.05) between the value of the variable for girls with and without healthcare career aspirations. The gap is measured as the difference between the average index computed among girls with healthcare career aspirations and the average index among girls without healthcare career aspirations. The last column indicates the average difference among EU27 countries. In this column, differences that are statistically significant (p-value < 0.05) are in* ***bold****.*

5.3.6 Access to information on different education and work opportunities

The final question analysed is from the PISA 2018 optional educational career questionnaire, which asks students whether they have undertaken one (or more) activities to find out about future education or work opportunities. Students can choose among the following options:

- I did an internship
- I attended a job shadowing or work-site visits
- I visited a job fair
- I spoke to a career advisor at my school
- I spoke to a career advisor outside of my school
- I completed a questionnaire to find out about my interest and abilities

- I researched the internet for information about careers
- I went to an organised tour in an ISCED 3-5 institution
- I researched the internet for information about ISCED 3-5 programmes

The analysis of this question helps discover whether there are any differences in the extent and type of information within and between career aspiration groups.

As we have done for other variables of the educational career questionnaire, we only comment on average differences within and between career-aspirations computed for the available countries.

Regarding gender differences (Table 35 to 0), we observe that within each career aspiration group, girls have a lower tendency to use information modes that involve the contact with other people or practical exposure to the professions (e.g. internships, career counselling, job fairs, job shadowing). Searching the internet for available information seems to be significantly more prevalent among girls than among boys within each career-aspiration group. For instance, within the STEM-career group, 13 percentage points more boys reporting to have done an internship than girls and 9 percentage points more boys report having attended job shadowing or a work fair. These results hint that girls' exposure to information on career and educational opportunities might still be limited. This could be the result of a choice (e.g., if girls prefer searching information anonymously without exposing their "unusual" interest for STEM) or the result of lack of opportunities (e.g., provided by the school or allowed by family socio-economic situation).

When we turn to the comparison of girls with different career aspirations (Table 38 to Table 40), we can observe similar patterns. Girls with STEM, ICT or healthcare career aspirations find information about future career or education opportunities through online research rather than through channels that allow them to be more exposed to the professions.

Table 35. Gender differences in the activities done to find out about future study or career opportunities within the STEM-career group (statistically significant results are in bold)

Have you done any of the following to find out about future study or types of work?	Gender gaps (proportion of girls – proportion of boys), average	Countries with the largest statistically significant gender gaps (value of the gap in parenthesis)[1]
I did an internship	**-0.13**	EL (-0.22), HU (-0.25), LT, (-0.29)
I attended job shadowing or work-site visits	**-0.09**	SI (-0.26), SK, (-0.15), EL (-0.16)
I visited a job fair	**-0.06**	SI (-0.18), DE (-0.16), EL/IT (-0.11)
I spoke to a career advisor at my school.	**-0.04**	SK (-0.13), ES (0.07)
I spoke to a career advisor outside of my school	**-0.07**	MT (-0.23), SI (-0.16), SK (-0.17)
I completed a questionnaire to find out about my interests and abilities	**0.04**	AT (0.12), ES (0.11), HR (0.14)
I researched the internet for information about careers	**0.08**	EL (0.14), ES (0.14), BE (0.12)
I went on an organised tour in an ISCED 3-5 institution	**-0.04**	EL (-0.13), IE (-0.08)
I researched the internet for information about ISCED 3-5 programmes	**0.09**	AT (0.17), BE (0.19) BG (0.19)

[1]The value of the difference is in parenthesis. The reported countries are those for which a significant (p-value lower than 0.05) gender gap was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls reporting that they engaged in a specific activity to find out about future career opportunities is higher than the percentage of boys reporting that they engaged in that specific activity. Vice-versa, a negative value of the difference means that on average the percentage of boys that they engaged in that specific activity to find out about future career opportunities is higher than the percentage of girls reporting that they engaged in the same activity.*

Table 36. Gender differences in the activities done to find out about future study or career opportunities within the ICT-career group.

Have you done any of the following to find out about future study or types of work?	Gender gaps (proportion of girls – proportion of boys), average	Countries with the largest statistically significant gender gaps (value of the gap in parenthesis)[1]
I did an internship	-0.03	DE (0.14), DK (0.47), IT (-0.23)
I attended job shadowing or work-site visits	**-0.07**	BG (0.23), EL (-0.21), PL (-0.23)
I visited a job fair	-0.06	BE (-0.17), IT (-0.24), PL (-0.18)
I spoke to a career advisor at my school.	0.01	DK (0.16)
I spoke to a career advisor outside of my school	**-0.06**	IT (-0.21), SI (-0.24) LT/PL (-0.16)
I completed a questionnaire to find out about my interests and abilities	0.06	BE (-0.31), DK (0.33), HU (0.23)
I researched the internet for information about careers	**0.14**	BE (0.25), DE (0.14), SI (0.25)
I went to an organised tour in an ISCED 3-5 institution	-0.02	BE (-0.25), EL (-0.17), LT (-0.19)
I researched the internet for information about ISCED 3-5 programmes	**0.14**	BE (0.54), IE (0.40), PL (0.27)

[1]The value of the gender gap is in parenthesis. The reported countries are those for which a significant (p-value lower than 0.05) gender gap was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls reporting that they engaged in a specific activity to find out about future career opportunities is higher than the percentage of boys reporting that they engaged in that specific activity. Vice-versa, a negative value of the difference means that on average the percentage of boys that they engaged in that specific activity to find out about future career opportunities is higher than the percentage of girls reporting that they engaged in the same activity.*

Table 37. Gender differences in the activities done to find out about future study or career opportunities within the healthcare-career group.

Have you done any of the following to find out about future study or types of work?	**Gender gaps (proportion of girls – proportion of boys), average**	**Countries with the largest statistically significant gender gaps (value of the gap in parenthesis)[1]**
I did an internship	**-0.08**	EL (-0.16), MT (-0.14), PL (-0.11)
I attended job shadowing or work-site visits	**-0.07**	EL (-0.13), LT (-0.15), SK (-0.11)
I visited a job fair	**-0.04**	EL (-0.20), PL (-0.12), BG/HR (-0.10)
I spoke to a career advisor at my school	0.002	-
I spoke to a career advisor outside of my school	**-0.04**	BG (-0.14), PL (-0.10), SK (-0.15)
I completed a questionnaire to find out about my interests and abilities	0.016	DE (0.23)
I researched the internet for information about careers	**0.057**	BE (0.17), HR (0.17), PL (0.13)
I went to an organised tour in an ISCED 3-5 institution	**-0.02**	BG (-0.13)
I researched the internet for information about ISCED 3-5 programmes	**0.07**	BG (-0.15), HR (0.19), MT (0.13)

[1] The value of the gender difference is in parenthesis. The reported countries are those for which a significant (p-value lower than 0.05) gender gap was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls reporting that they engaged in a specific activity to find out about future career opportunities is higher than the percentage of boys reporting that they engaged in that specific activity. Vice-versa, a negative value of the difference means that on average the percentage of boys that they engaged in that specific activity to find out about future career opportunities is higher than the percentage of girls reporting that they engaged in the same activity.*

Table 38. Differences in the activities done to find out about future study or career opportunities, between girls with and without STEM career aspirations

Have you done any of the following to find out about future study or types of work?	Difference (proportion of girls with STEM career aspirations – proportion of girls without STEM career aspirations), EU27 average	Countries with the largest statistically significant gap (value of the gap in parenthesis)[1]
I did an internship	**-0.05**	HU (-0.11), LT (-0.11), SI (-0.10)
I attended job shadowing or work-site visits	0.00	EL (-0.09), HU (0.10), LT (-0.08)
I visited a job fair	0.01	DE (-0.15), ES (0.09)
I spoke to a career advisor at my school	**-0.04**	DE (-0.15), SI (-0.09)
I spoke to a career advisor outside of my school	**-0.03**	MT (-0.15), SK (-0.08)
I completed a questionnaire to find out about my interests and abilities	0.02	AT (0.08), ES (0.11), HR (0.09)
I researched the internet for information about careers	**0.04**	ES (0.09), IE (0.06), LT (0.10)
I went to an organised tour in an ISCED 3-5 institution	0.00	AT (0.10)
I researched the internet for information about ISCED 3-5 programmes	**0.04**	ES (0.07), HU (0.10), IE (0.16)

[1]The value of the difference is in parenthesis. The reported countries are those for which a significant (p-value lower than 0.05) gender gap was found. Up to three countries are reported.

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls within the STEM-career group reporting that they engaged in a specific activity to find out about future career opportunities is higher than the percentage of girls with all other career aspirations who engaged in the same activity. Vice-versa, a negative value of the difference means that on average the percentage of girls without STEM career aspirations reporting that they engaged in a specific activity is higher than the percentage of girls within the STEM-career group who engaged in the same activity.*

Table 39. Differences in the activities done to find out about future study or career opportunities, between girls with and without ICT career aspirations

Have you done any of the following to find out about future study or types of work?	Difference (proportion of girls with ICT career aspirations – proportion of girls without ICT career aspirations), EU27 average	Countries with the largest statistically significant gap (value of the gap in parenthesis)[1]
I did an internship	0.01	AT (-0.26), DK (0.42), IT (-0.20)
I attended job shadowing or work-site visits	-0.04	BG (0.24), LT (-0.12), PL (-0.20)
I visited a job fair	-0.04	BE (-0.18), IT (-0.21), PL (-0.14)
I spoke to a career advisor at my school	-0.02	DK (0.14), PL (-0.21)
I spoke to a career advisor outside of my school	-0.05	IT (-0.24), PL (-0.17), SI (-0.19)
I completed a questionnaire to find out about my interests and abilities	0.01	BE, (-0.36), DK (0.26), HU (0.23)
I researched the internet for information about careers	**0.1**	BE (0.31), IE (0.19), SI (0.23)
I went to an organised tour in an ISCED 3-5 institution	-0.02	EL (-0.18), LT (-0.17), SI (0.19)
I researched the internet for information about ISCED 3-5 programmes	0.1	BE (0.50), IE (0.36), HR (0.15)

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls within the ICT-career group reporting that they did they engaged in a specific activity to find out about future career opportunities is higher than the percentage of girls with all other career aspirations who engaged in the same activity. Vice-versa, a negative value of the difference means that on average the percentage of girls without ICT career aspirations reporting that they engaged in a specific activity is higher than the percentage of girls within the ICT-career group who engaged in the same activity.*

Table 40. Differences in the activities done to find out about future study or career opportunities, between girls with and without career aspirations in the healthcare sector.

Have you done any of the following to find out about future study or types of work?	Difference (proportion of girls with – proportion of girls without career aspirations in the healthcare sector), EU27 average	Countries with the highest statistically significant gap (value of the gap in parenthesis)[1]
I did an internship	**-0.08**	AT (-0.06) HU (-0.17), SK (-0.12)
I attended job shadowing or work-site visits	**-0.07**	AT (-0.10), HU (-0.10), MT (-0.09)
I visited a job fair	**-0.04**	AT (-0.08), DE (-0.14), LT (0.08)
I spoke to a career advisor at my school	0.00	DE (-0.12), HU (-0.14), AT (-0.07)
I spoke to a career advisor outside of my school	-0.04	AT (-0.06), HU (-0.07), SK (-0.07)
I completed a questionnaire to find out about my interests and abilities	0.02	LT (0.06)
I researched the internet for information about careers	**0.06**	LT (0.05), SI (0.09), SK (0.06)
I went to an organised tour in an ISCED 3-5 institution	**-0.02**	HU (-0.07), LT (0.07), SK (0.06)
I researched the internet for information about ISCED 3-5 programmes	**0.07**	AT (0.07), HR/LT (0.08), SI (0.10)

***Source**: Own computations from OECD PISA 2018 microdata. The average is computed among the following EU countries that distributed the educational career questionnaire: Austria, Belgium, Bulgaria, Denmark, Spain, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Malta, Poland, Slovakia, Slovenia. Statistically significant differences (p-value < 0.05) are in **bold.** A positive value of the difference means that on average the percentage of girls within the healthcare-career group reporting that they engaged in a specific activity to find out about future career opportunities is higher than the percentage of girls with all other career aspirations who engaged in the same activity. Vice-versa, a negative value of the difference means that on average the percentage of girls without healthcare career aspirations reporting that they engaged in a specific activity is higher than the percentage of girls within the healthcare-career group who engaged in the same activity.*

6 Econometric analysis

Box 8.1: Summary of econometric analysis results

- The econometric analysis concentrates on career aspirations in STEM and ICT. It explores drivers and deterrents of girls' career aspirations in STEM and ICT, holding other factors constant. This is important given the correlation among the different factors affecting career aspirations.
- We have estimated country-by-country and multi-country models. The former focus on individual drivers of career aspirations (as measured in the PISA microdata). Multi-country models allow focus on the effect of country-level variables, e.g., labour market characteristics, school system and average digital education in a country.
- Overall, we find that, once other factors are kept constant, only some of the theoretical drivers of career aspirations seem to still have a strong effect. In particular, science competences appear to be the strongest driver, only mediated by some other motivational and family factors.
- The results of the econometric analysis are summarised in Table 41, which connects the theoretical drivers to the PISA 2018 variables.

Table 41. Summary of econometric analysis results in relation to the conceptual framework

SCCT factor	PISA 2018 proxy	Econometric results
STEM performance as a result of STEM learning experiences	PISA competences in science	PISA Science competences are a strong predictor of STEM and ICT career aspirations. The effects are stronger for boys than for girls.
STEM interest and motivation	• Competitiveness • Motivation to master goals and tasks • Value of school	Of these three variables, only the motivation to master goals and tasks appear to be still a relevant driver, but the influence of motivational variables is stronger for boys than for girls. Motivational variables do not appear to influence career aspirations in ICT.
Family factors: socio-economic status, presence of role models in the family	• Economic, Socio-Cultural Status (ESCS) • Parents in STEM • Parental emotional support • Migration background • Value of school	Having a parent in STEM is still a strong predictor of both girls' and boys' career aspirations in STEM and ICT. The effects are stronger for boys than for girls.

Peer factors: peer-choices and support of the group of peers	• Peer competition • Peer cooperation • Sense of belonging	No effect found
School factors: quality of teaching and career guidance	• Disciplinary climate • Teachers' support • Career guidance	No effect found
Country level variables: cultural factors, characteristics of the education system and of teachers in a country	• Proxies for gender equality in the labour market • Vocational education system • Teachers with digital skills	Only greater gender equality in the labour market for STEM is found to be significantly associated with a higher probability for girls to choose a STEM career. Differences in career aspirations in ICT, however, widen with higher equality in the labour market for STEM. Teachers' digital skills do not affect the gap in career aspirations in STEM but they widen the gender differences in career aspirations in ICT.

6.1 Approach to the econometric analysis

The descriptive analysis presented in the previous section identifies emerging tendencies from the data and probable associations among the main variables of interest.

Although informative, a simple descriptive analysis of the kind developed above cannot solve a fundamental analytical issue: it does not allow measuring the association between career aspirations and each of its potential drivers or deterrents, *holding other factors constant.* Where this is possible, the evidence of association will be stronger. The importance of holding other factors constant in the analysis can be seen if we consider how strongly the drivers/deterrents accounted for in our models are associated with each other. A typical example are family background variables: parents in STEM may be among those with the highest socio-cultural background. In turn, parents with a high socio-cultural background may be more supportive of their children's education or development of their career interests. If that is the case, whenever we relate parents' socio-economic index (ECSC) with STEM aspirations in a descriptive way, we cannot be sure to capture only the association between socio-cultural background and STEM aspirations, rather than the combined association of socio-cultural background, parental profession, and emotional support with STEM career aspirations. To be able to measure the association of each driver or deterrent with career aspirations, it is necessary to apply regression techniques.

We estimate **country-by-country and multi-country** econometric models. For the country-by-country models, we use **logistic regressions**, while the multi-country models are estimated using **multilevel regressions (three-level linear probability**

models). Our two dependent variables are 0/1 variables, equal to 1 if students indicate that they expect to work in STEM or ICT at the age of 30.[111]

Our modelling strategy is based on a **sequential modelling approach**. This starts with the estimation of the simplest possible model, i.e., one with the smallest set of variables, and then proceeds with adding groups of variables at each step. The dependent variable in all models is either STEM or ICT career aspirations.

- **Model 1** includes only PISA (Science) competence as explanatory variable. The results of this model can be interpreted as the changes in career aspirations if science competences in the adolescent population change.
- **Model 2:** Model 1 with the addition of interest and motivational variables. The results from this model tell us how different levels of interest and motivation would change STEM / ICT aspirations for adolescents with the same level of school performance.
- **Model 3:** Model 2 with the addition of family characteristics and peer-level factors. This model focuses on how changes in family and peer characteristics could affect students with similar competencies and motivation.
- **Model 4:** Model 3 with the addition of school-level factors. This model investigates how potential changes in school factors could change occupational choices for students with similar competences, motivation, and social/family background.

To be consistent across models, we exclude variables that are not available for all EU27 Member States. Hence, we exclude the educational career variables and the self-efficacy/fear of failure indexes. In addition, although the variable on ICT career aspirations is available for all countries, sample sizes for 13 out of 27 EU Member States are too small to estimate reliable results.[112] Hence, the models on ICT career aspirations are estimated only on 14 countries.

The final analytical step estimates a multi-level model, which pools together PISA microdata for all EU27 countries and the UK. The advantage of the multi-level modelling approach is that it allows accounting for the hierarchal structure of the PISA dataset, where individuals (pupils) are nested into schools and schools are nested into countries. The consideration of the structure of the data in the estimation allows a more precise inference, and hence a more reliable estimation of the effects. The multi-level models included all individual-level PISA variables included in Model 4 above.[113] In addition, the models included country-level variables, which proxy either the general degree of gender equality in STEM in the country, or characteristics of the educational systems. The main country-level variables analysed in the multi-level model are:

[111] Results using health career aspirations as dependent variable are available in the annex to this report.

[112] We used a cell size of 20 as reliability threshold, following Eurostat reliability limits (see: https://circabc.europa.eu/sd/a/a31fe118-3b05-4d85-b5b2-a5c4b5511fc9/Guidelines%20for%20Publication.pdf)

[113] More precisely, the models for career aspirations in STEM control for: science competences, value of school, motivation to master tasks, economic and socio-cultural status, parental emotional support, migration background, parent in STEM and teachers' interest. The models for ICT control for: science abilities, attitudes towards competition, value of school, motivation to master tasks, economic and socio-cultural status, parental emotional support, migration background, parents in STEM, peer competition, disciplinary climate and teacher support index.

- **Proxies for general labour market conditions in ICT and STEM and the degree of gender equality in the labour market for STEM**:
  - Percentage of women doctoral graduates in STEM: source, Eurostat, online data code: educ_uoe_grad02 [114]
  - Percentage of women employed in science and technology: Eurostat, online data code: hrst_st_ncat
  - Gender pay gap in science and technology. Source: She Figures (2018), Table 5.1[115]
  - Percentage of female researchers (FTE), Source: UNESCO[116]women researchers in HE
  - Employment of ICT specialists by sex. Source: Eurostat, online data code: isoc_sks_itsps
- **Proxies for the overall level of digital skills in the Member State and school**:
  - Percentage women/men with basic or above basic overall digital skills. Source: Eurostat, online data code: tepsr_sp410
  - Percentage of young adults (women/men) holding a vocational or tertiary education. Source: Eurostat, online data code: edat_lfs_9914
  - Percentage of teachers for whom the 'use of ICT for teaching' was included in their formal education or training. Source: OECD, TALIS indicators[117]
  - Percentage of teachers who frequently or always let students use ICT for projects or class work. Source: OECD, TALIS indicators
  - Percentage of teachers who felt 'well prepared' or 'very well prepared' for the use of ICT for teaching. Source: OECD, TALIS indicators
- **Proxies for vocational education system in the country:**
  - Percentage of students enrolled in a vocational education programme (computed from the PISA 2018 microdata)
- **Proxies for peer effects in STEM subjects at the country level:**
  - Percentage of top performers in mathematics. Source: Education and Training Monitor (2020), Chapter 6, computed from EU-SILC and PISA data[118]
  - Percentage of top performers in science. Source: Education and Training Monitor (2020), Chapter 6, computed from PISA data[119]

We also control for additional proxies for the gender balance in science and for the general level of education in the country[120]. The effect of the additional variables in

[114] This data covers the following STEM-related fields of study: Biological and related sciences (EF051); Environment (EF052); Physical sciences (EF053); Mathematics and statistics (EF054); Information and Communication Technologies (EF061); Engineering and engineering trades (EF071); Manufacturing and processing (EF072); Architecture and construction (EF073).

[115]https://data.europa.eu/euodp/en/data/dataset/she-figures-2018-gender-in-research-and-innovation/resource/377b1eaa-eb68-4cd7-a342-0ee5ab2ba515

[116] http://data.uis.unesco.org/#

[117] https://stats.oecd.org/Index.aspx?QueryId=97203#

[118] https://op.europa.eu/webpub/eac/education-and-training-monitor-2020/en/chapters/chapter6.html

[119] https://op.europa.eu/webpub/eac/education-and-training-monitor-2020/en/chapters/chapter6.html

[120] Specifically, the models control for: percentage of women doctoral graduates in STEM (Source: Eurostat, indicator educ_uoe_grad02), women to men ratio of authorships in all fields of R&D, 2013-2017 (Source:

not explored in detail as they do not seem to significantly explain career aspirations, but all results are available in the annex to this report.

To allow a more intuitive interpretation of the results and cross-country comparisons, we present all results in a graphical way. Each figure for the country-by country models displays the countries under analysis on the horizontal axis, and the estimated effects of each variable on the vertical axis. All effects can be interpreted as **the change in the probability of having an aspiration (in STEM or ICT) associated with a one-standard deviation[121] increase in the potential driver or deterrent under consideration**. The graphs for the multi-level models show how the predicted probability of developing career aspirations in STEM or ICT changes as the level of each variable (displayed in the horizontal axis) changes.

Besides point estimates, all figures include 95% confidence intervals, which allow assessing the statistical significance of the estimated effects.[122]

6.2 Individual level variables

This section comments on the results of individual level variables, both in the country-by-country models (Models 1 to 4) and the multi-level model.

6.2.1 Model 1: Does school performance explain career aspirations?

Model 1 explores the relationship between school performance, as measured by PISA competences, and career aspirations in STEM and ICT. The PISA 2018 microdata includes scores in science, reading and mathematics. As these scores are highly correlated with each other, it is not advisable to include them together in the same regression.[123] The results presented in this section show the association between **science competences** and careers aspirations in STEM and ICT sectors. Results using other competences are qualitatively similar.[124]

Error! Reference source not found. and Figure 6 present the results for STEM and ICT career aspirations, respectively. As indicated also in the descriptive analysis, science performance is an important driver of both girls' and boys' career aspirations in STEM professions. A girl with a 100-point (one standard deviation) higher index of science competence is between 2 percentage points (in Austria) and 6 percentage points (in Sweden) more likely to state that she thinks that she will be in a STEM profession at the age of 30. The effects are higher for boys, ranging between 2.5 percentage points in Finland and 14 percentage points in Portugal. Only in Slovenia is the effect very small (and not statistically significant) for boys, while it is still positive and significant for girls. The stronger influence of science competences as a driver of boys' rather than girls' career aspirations is also statistically significant in most countries. The differences are not statistically significant in Finland, Austria, Bulgaria, Croatia, Cyprus, Estonia, Hungary, Lithuania, Poland, Romania, Slovakia, and the UK.

DG RTD, She figures 2018, Figure 7.1) proportion of grade A staff among all academic staff (Source: DG RTD, She figures 2018, Figure 6.4), percentage of women among the total number of presidents and member of the highest decision making body in national academies of science (Source: European Institute for Gender Equality, Gender Statistics Database), percentage of women among the total number of presidents and member of the highest decision making body in research-funding organisations (Source: European Institute for Gender equality, Gender Statistics Database), share of young adults holding a vocational or tertiary education, by sex (Source: Eurostat, online indicator code: edat_lfs_9914), and participation in adult training (Source: Eurostat, online indicator code: trng_lfse_01)

[121] For binary variables the marginal effect is the change in the dependent variable associated with a change of the independent variable from 0 to 1.

[122] If the confidence interval does not include "0", the estimated effect is significant at 5%.

[123] Econometrically, this problem is known as multicollinearity.

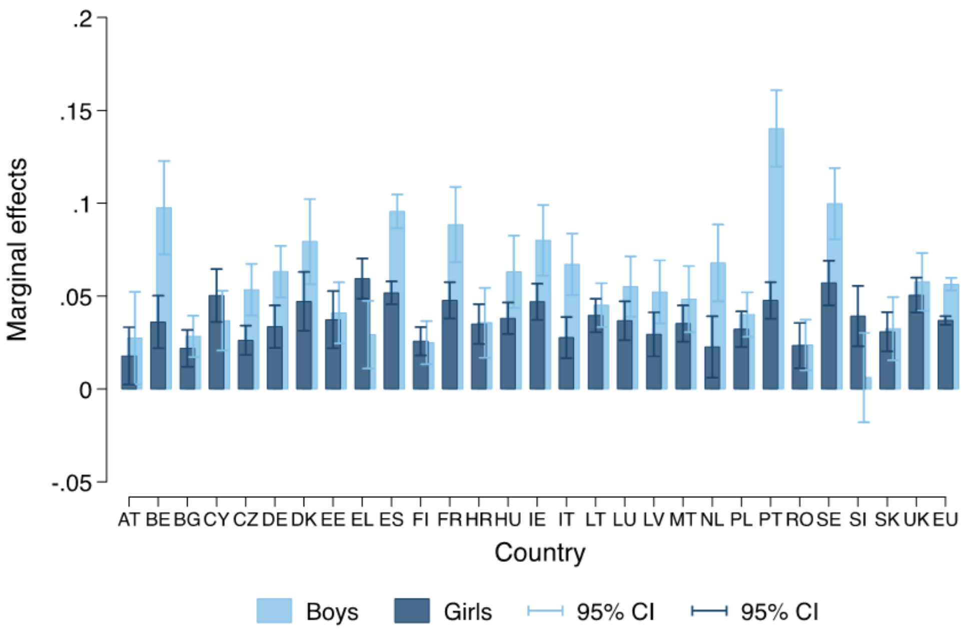
[124] These are available in the annex to this final report.

In the above countries, science competences drive boys' and girls' career aspirations in STEM to a similar extent.

Similar results are found for ICT career aspirations. Science competences significantly drive both girls' and boys' career aspirations in the ICT sector (except for Spain, where the effect is insignificant for boys). Gender differences are more marked in the case of ICT. The effects for girls are of a magnitude of around 2 percentage points or smaller, while the effects for boys range between 3 (e.g., in Estonia, Greece, Cyprus) and 10 percentage points (for Romania). These differences are statistically significant in all the countries analysed, except for Estonia and Spain.

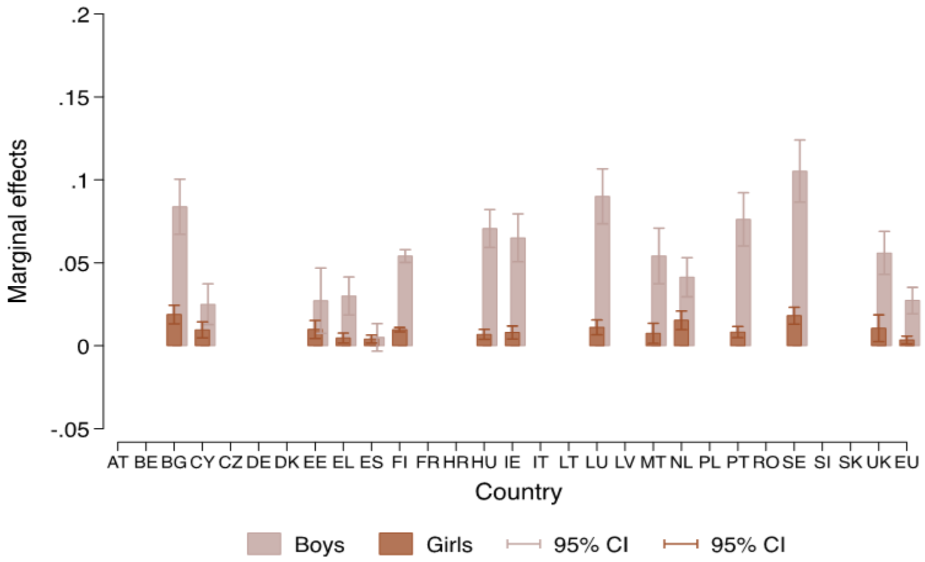
When looking at the effect of science performance in the multi-country context, we see that the gap in STEM career aspirations is not affected by higher levels of science competences, while for ICT the gap widens for boys and girls with high levels of science competences.

Figure 5. Influence of PISA Science competences on girls' and boys' career aspirations in STEM



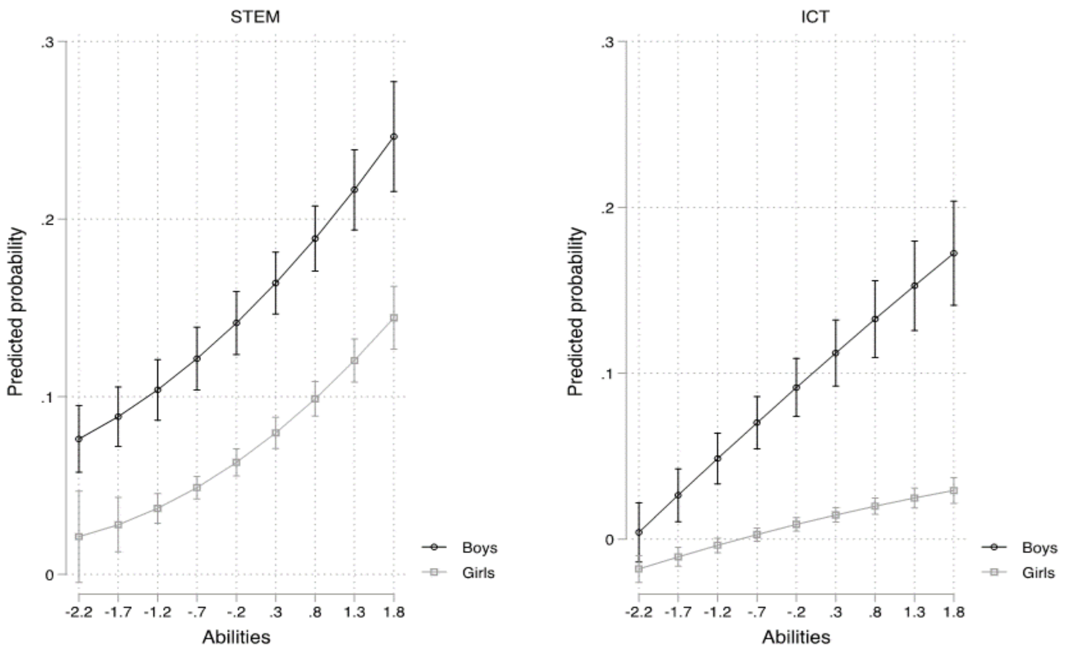
Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of the science competence on the probability of have career aspirations in STEM. The effects are computed for 100-points increase in science competence. "EU" is the average across EU27 countries.

Figure 6. Influence of science competence on girls' and boys' career aspirations in ICT professions



Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of science competence on the probability of having career aspirations in ICT. The effects are computed for 100-points increase in science competence. "EU" is the average across EU27 countries.

Figure 7. Effect of science competences on the predicted probability of having career aspirations in STEM or ICT - Multilevel model



Source: Own estimations using PISA 2018 Microdata. The graph shows how the predicted probability of having career aspirations in STEM (left panel) or ICT (right panel) changes as OECD PISA science competences increase for girls and boys. The model for STEM includes all EU27 Member States and the UK. The model for ICT includes 13 Member States and the UK.

6.2.2 Model 2: How do interest and motivation drive career aspirations?

Model 2 investigates the extent to which interest and motivational variables are important drivers for girls' career aspirations in STEM and ICT professions, once science competences are kept constant. As done in the previous section, gender differences are also explored and noted when relevant.

Model 2 focuses on the following motivational variables (defined earlier when presenting the results of the descriptive analysis):

- Attitudes towards competition
- Motivation to master goals
- Value of school

It should be noted that we have not included the variables that were missing for some countries, e.g., fear of failure and self-efficacy, which are missing for Belgium, to have a consistent sample of countries across the models.

Attitudes towards competition are not found to be a significant driver of girls' career aspirations in STEM or ICT.[125] For the other two variables analysed in Model 2 we found that:

- **The value of school index** (Figure 8 and Figure 9) does not significantly drive girls' career aspirations in STEM. Figure 8 suggests that only in **Germany, Latvia and the Netherlands** is a higher value of the index a predictor for STEM career aspirations. In Germany, other things being equal, a girl who values school 100-point more than another girl with the same science competence and degree of competitiveness, is 5 percentage points more likely to declare that she would like to work in a STEM profession when she is 30. This association is slightly weaker in the other two countries, 1.3 percentage points in Latvia and 2 percentage points in the Netherlands. In **Greece,** girls who value school more are significantly **less likely** to develop an interest in STEM (-2 percentage points for a 100-point increase in the index). The association between value of school and career aspirations in STEM is generally stronger among boys (except for Germany), but it is statistically significant in only eight countries**: Belgium, Germany, Croatia, Italy, Poland, Sweden, Slovenia and the UK**. The strength of the association for boys ranges between 2-3 percentage points in these countries and is significantly higher than for girls in the above eight countries. Germany is an exception, as girls are 1 percentage points more likely than boys to be interested in a STEM profession if they have a higher value of school index. As to **career aspirations in ICT**, the value of school index does not display any significant association with the probability of developing an interest in ICT professions, both for boys and for girls. The multilevel model results (Figure 10) confirm the country-by-country results. The gap in career aspirations in STEM widens for higher levels of value of school (keeping other factors constant) but does not change for career aspirations in ICT.
- **The motivation to master goals index** (Figure 11 and Figure 12). seems to positively drive career aspirations in STEM.[126] For **girls, Cyprus, Estonia, Greece, Spain, Ireland, Lithuania, Luxembourg, Latvia, Slovenia, UK** display a positive association between motivation and STEM career aspirations.

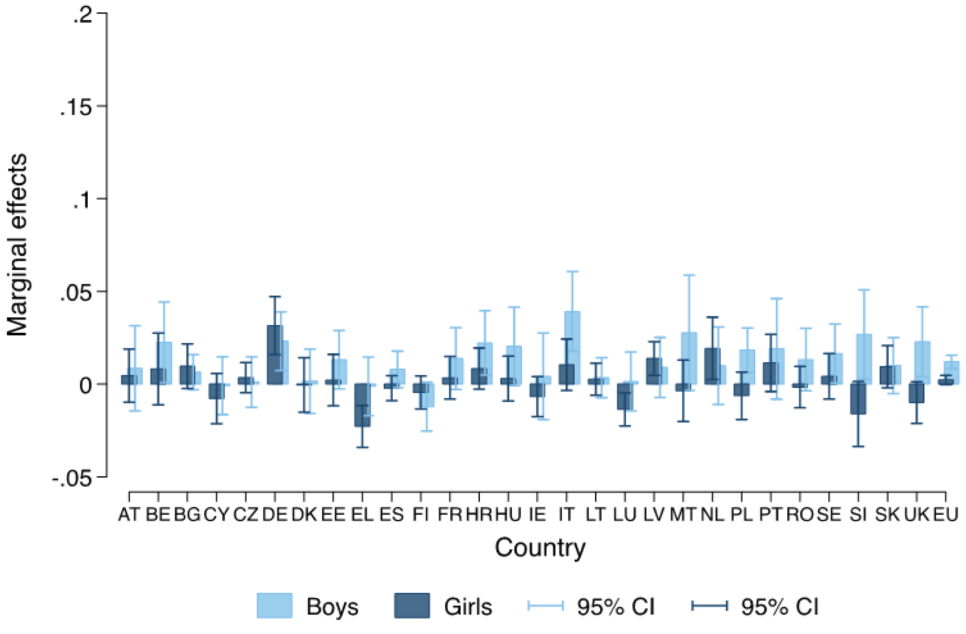
[125] Results are not reported in the main text but are available as an appendix to this report.

[126] The only exceptions are Germany and Denmark for girls' career aspirations only, where the motivation to master goals seems to be a negative driver. For Denmark this association is not significant, for Germany, it is significant and around 2 percentage points for a 100-point increase in the motivation to master goals index.

In these countries, a 100-point increase in the motivation index is associated with 1 to 2 percentage points higher probability of aspiring to STEM professions for girls, keeping other factors (i.e., science competences, value of school and attitude towards competition) constant. This association is in general stronger among boys than girls, and the difference in the effect for boys and girls is statistically significant in 14 out of the 28 countries analysed (**Belgium, Germany, Denmark, Czechia, Spain, Finland, France, Hungary, Ireland, Italy, Luxembourg, Netherlands, Sweden, and the UK)**. Things look different for career aspirations in the ICT sector, where motivational factors do not appear to significantly drive either girls' or boys' interests in ICT professions. **In Spain and Greece**, the motivation to master tasks seems to be a **deterrent for boys,** rather than a driver of career aspirations in the ICT sector. The multi-level modelling results (Figure 13) show that the motivation to master goals widens gender differences in career aspirations in STEM and narrows the gaps for ICT career aspirations. The results for ICT is entirely driven by the effect on boys: overall, in the EU27 and the UK, it is seems that boys with higher levels of motivation choose other careers than the ICT professions.

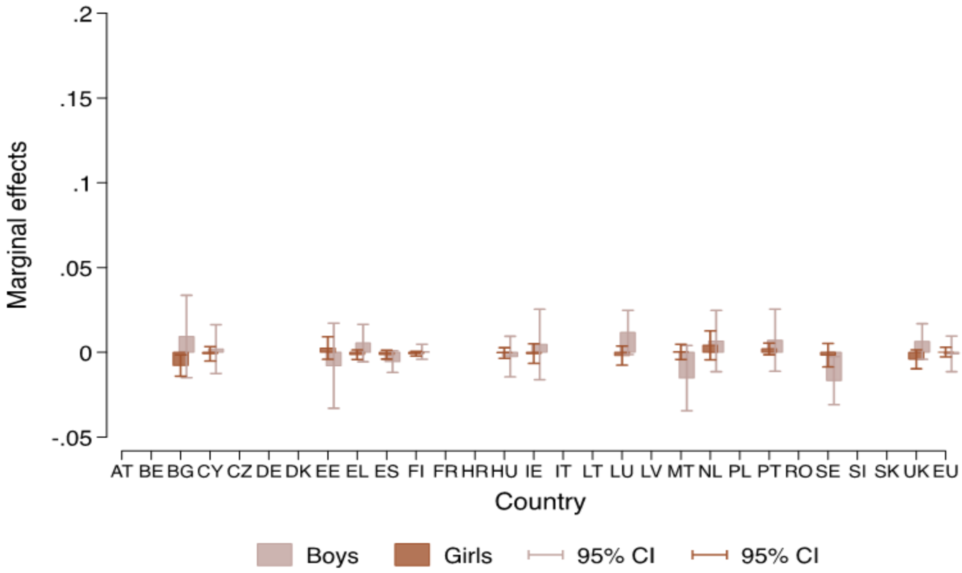
Overall, this section shows that, once science competences are kept constant, interest and motivational variables lose importance in driving both girls' career aspirations and gender differences in aspirations. Despite that, **there is some evidence that motivation drives more boys than girls towards choosing a career in STEM**.

Figure 8. Effect of value of school index on girls' and boys' career aspirations in STEM



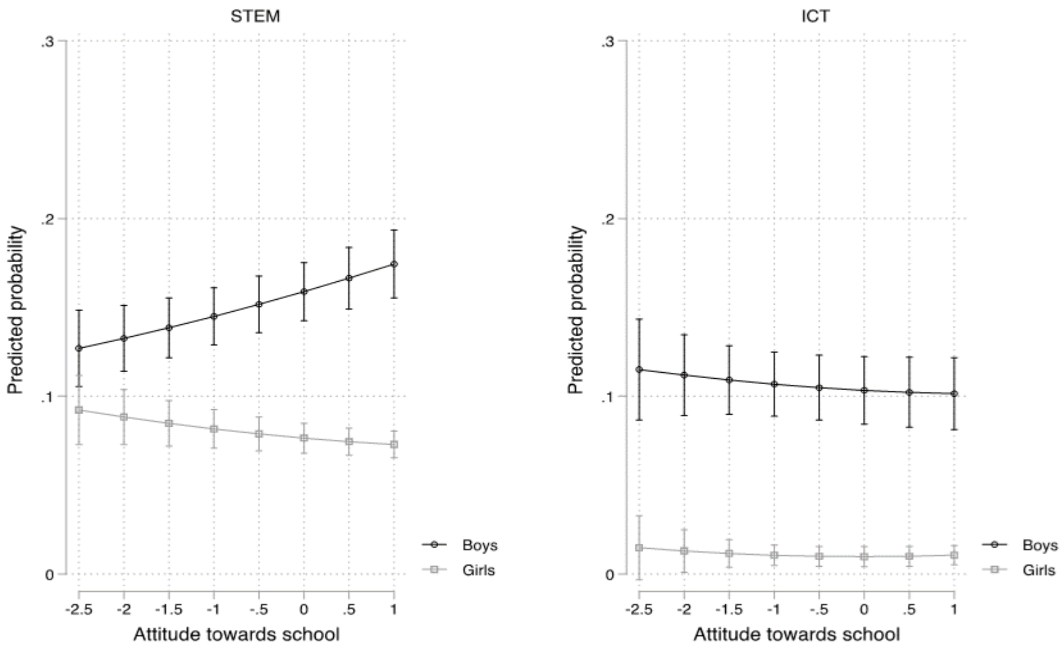
Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of the "value of school" index on the probability of have career aspirations in STEM. "EU" is the average across EU27 countries. The model additionally controls for science competences, attitudes towards competition and motivation to master tasks index.

Figure 9. Effect of value of school index on girls' and boys' career aspirations in ICT



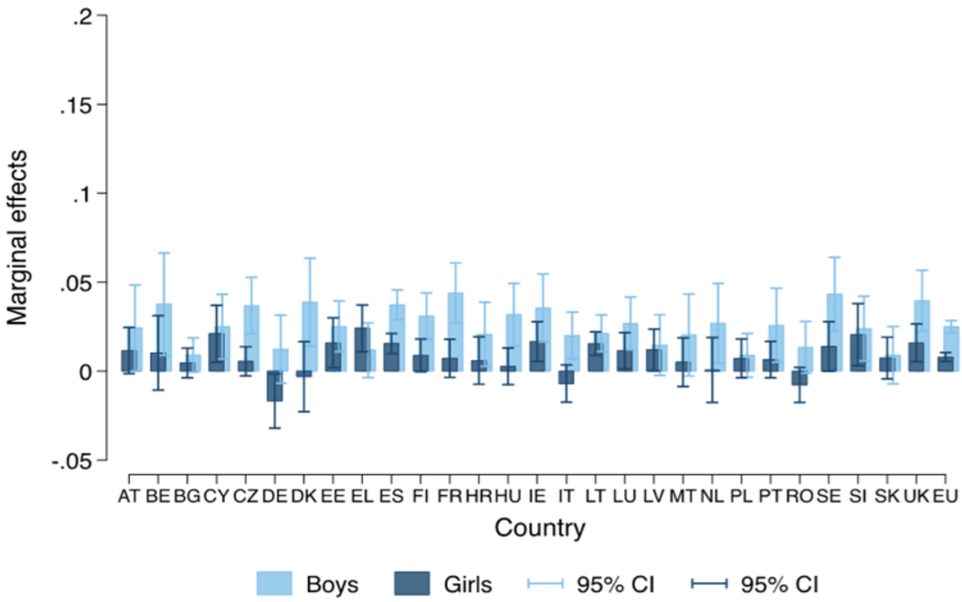
Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of the "value of school" index on the probability to have career aspirations in ICT. "EU" is the average across EU27 countries. The model additionally controls for science competences, attitudes towards competition and motivation to master tasks index.

Figure 10. Effect of value of school index on the predicted probability of having career aspirations in STEM or ICT, for boys and girls – multilevel model



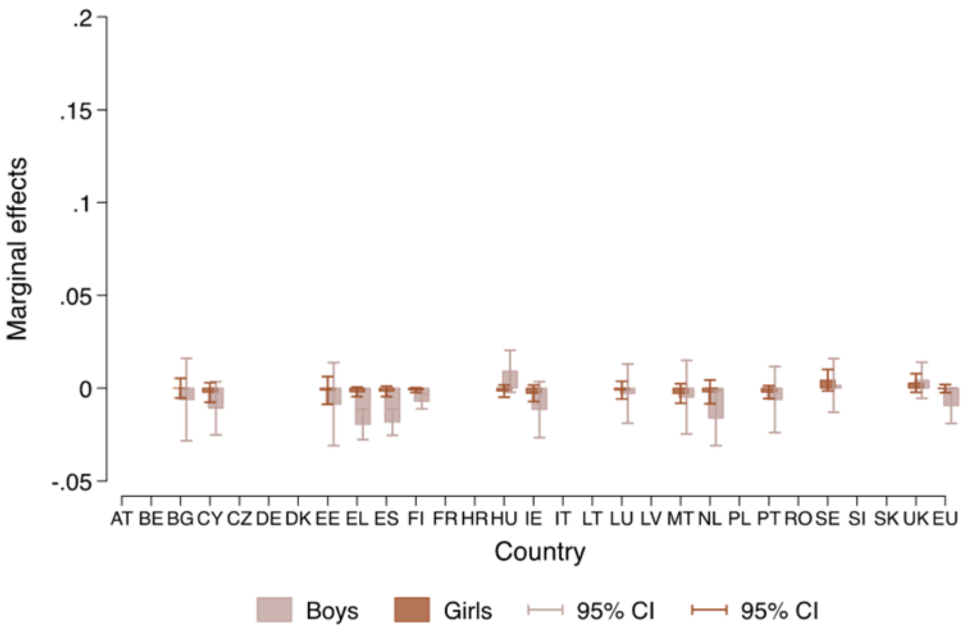
Source: Own estimations using PISA 2018 Microdata. The graph shows how the predicted probability of having career aspirations in STEM (left panel) or ICT (right panel) changes as the value of school index increases for girls and boys. The model for STEM includes all EU27 Member States and the UK. The model for ICT includes 13 Member States and the UK.

Figure 11. Effect of motivation to master tasks index on girls' and boys' career aspirations in STEM



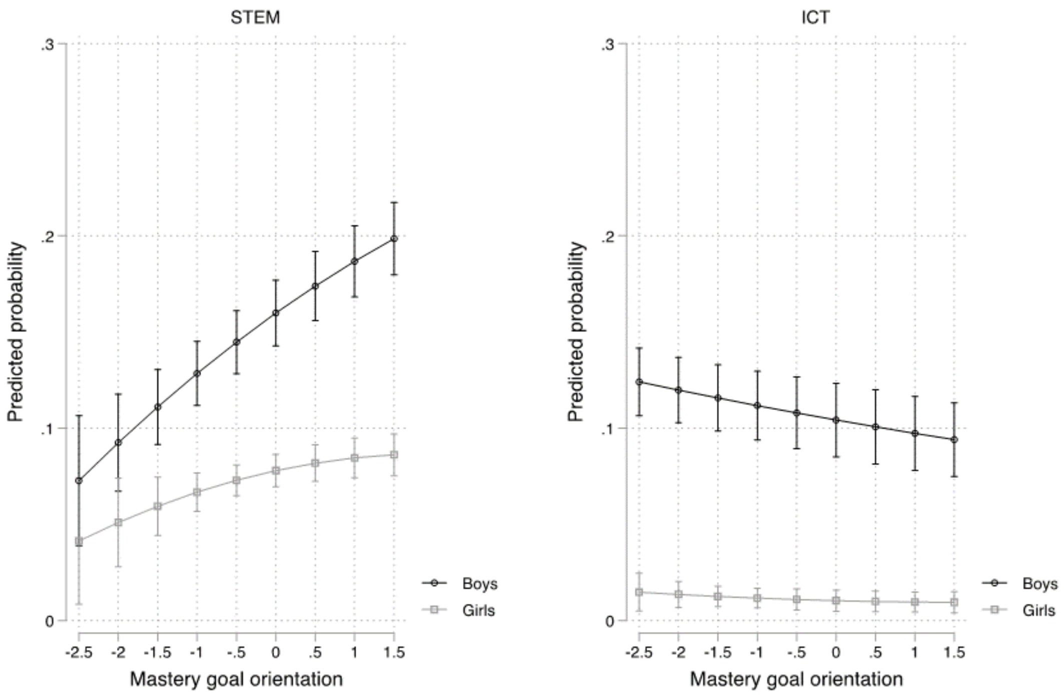
Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of the "motivation to master task" index on the probability to have career aspirations in STEM. "EU" is the average across EU27 countries. The model additionally controls for science competences, attitudes towards competition and value of school index.

Figure 12. Effect of motivation to master tasks index on girls' and boys' career aspirations in ICT



Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of the "motivation to master task" index on the probability of have career aspirations in ICT. "EU" is the average across EU27 countries. The model additionally controls for science competences, attitudes towards competition and value of school index.

Figure 13. Effect of motivation to master tasks on the (predicted) probability of having career aspirations in STEM and ICT – Multilevel model.



Source: Own estimations using PISA 2018 Microdata. The graph shows how the predicted probability of having career aspirations in STEM (left panel) or ICT (right panel) changes as the motivation to master tasks index increases for girls and boys. The model for STEM includes all EU27 Member States and the UK. The model for ICT includes 13 Member States and the UK

6.2.3 Model 3: How important are family and peer factors in driving career aspirations in STEM and ICT?

Model 3 focuses on the effect of family and peer factors as drivers of boys' and girls' career aspirations in STEM and ICT. The results of Model 3 keep both science competences and interest and motivational variables constant. The family and peer factors included in the models are the following (defined above in the descriptive section):

- **Family background variables**: Economic and socio-cultural status (ESCS) index in PISA 2018, Parents in a STEM profession, Parents emotional support, migration background
- **Peer-level variables**: peer competition index, peer cooperation index, sense of belonging to the peer group.

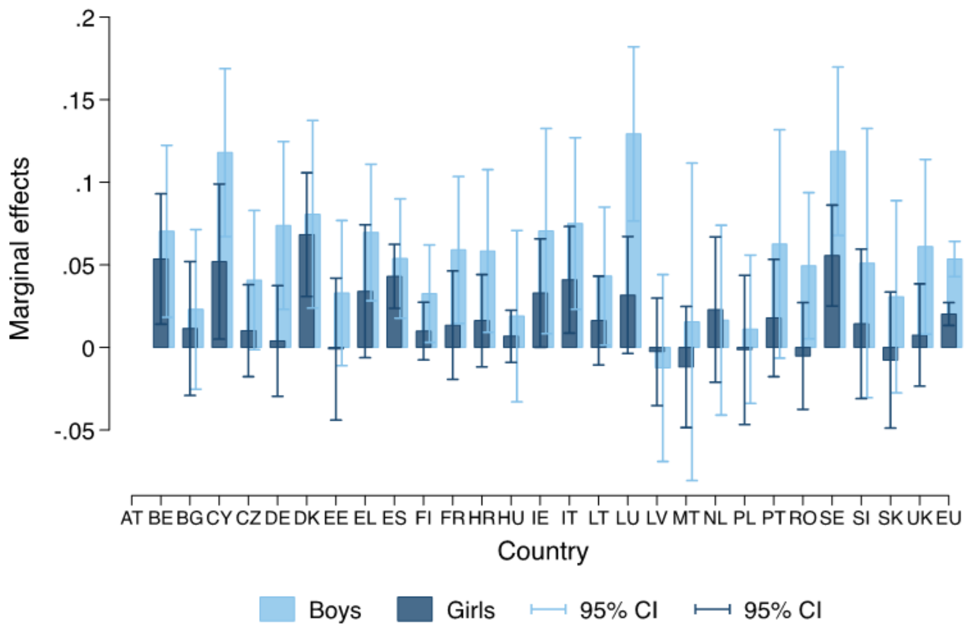
In what follows, we only comment on the results of the analysis where there is greater statistical and conceptual relevance. The full results are available as an appendix to this report. Not surprisingly, the peer-level variables do not appear to be significant in the single-country models, confirming the already weak evidence found at the descriptive level.

Among the family background variables, **having a parent in STEM** (Figure 14 and Figure 15) remains a strong predictor of both boys' and girls' career aspirations in STEM, even after keeping potential other drivers constant. For girls, the largest effect is found in Sweden, where a girl with otherwise the same characteristics has a 5.5

percentage point higher probability to be interested in a STEM profession than other girls with the same characteristics. The effects are stronger for boys, where the largest (and statistically significant) effect is found in Luxembourg, around 13 percentage points. **Differences across genders**, however, are **statistically significant only in Bulgaria, Germany, Luxembourg, Sweden**, suggesting that parental role models or the general influence from the family is a driver for career aspirations of all adolescents, rather than just girls. The effect of STEM parents on career aspirations in ICT are qualitatively similar, but all effects are less precisely estimated.[127]

The multi-country models confirm the results of the single-country models (see Figure 16). Overall in the EU27 Member States both boys and girls who have a parent in STEM are more likely to develop career aspirations in STEM and ICT, but the effect is stronger for boys.

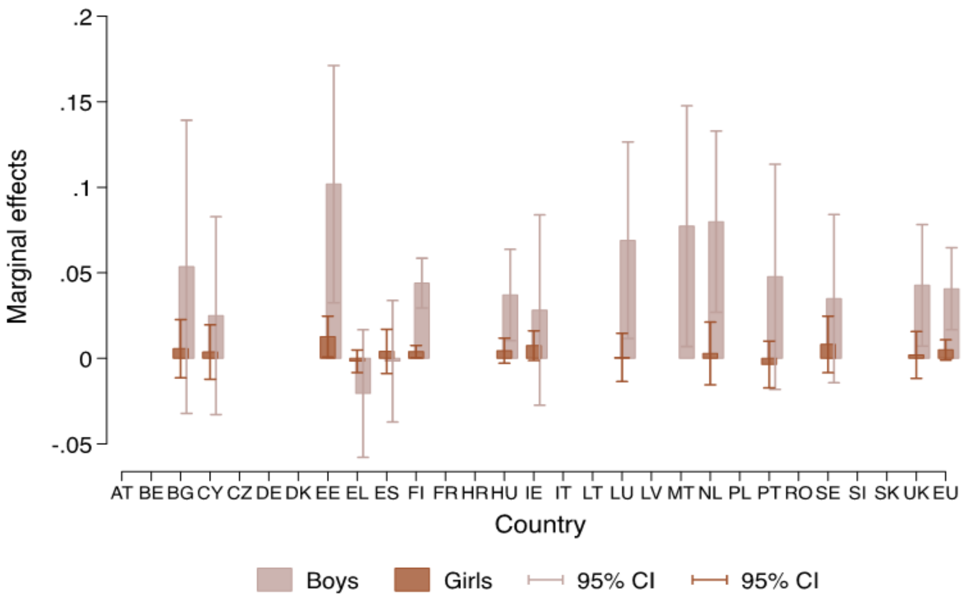
Figure 14. Effect of having a parent in STEM on girls' and boys' career aspirations in STEM.



Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of the having a parent in STEM on the probability to have career aspirations in STEM. "EU" is the average across EU27 countries. The model additionally controls for science competences, attitudes towards competition, motivation to master goals, and value of school index and the other family-background and peer-level variables mentioned in the main text in this section.

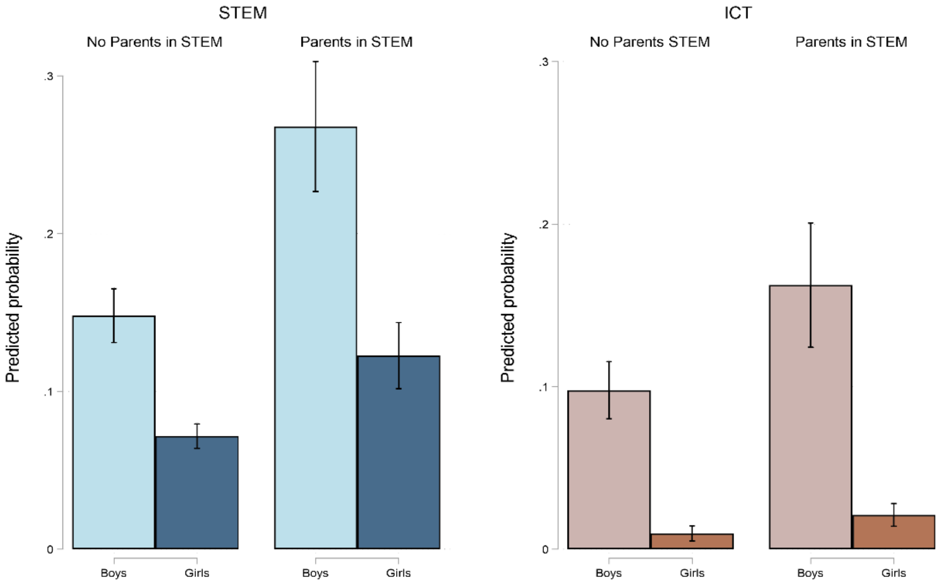
[127] It should be noted that in some cases results are small and non-statistically significant. These are cases of countries where the number of parents in STEM is small, and hence there is no sufficient sample size for the estimates to be reliable.

Figure 15. Effect of having a parent in STEM on girls' and boys' career aspirations in ICT.



Source: Own estimations using PISA 2018 Microdata. The graph shows the effect of the having a parent in STEM on the probability to have career aspirations in ICT. "EU" is the average across EU27 countries. The model additionally controls for science competences, attitudes towards competition, motivation to master goals, and value of school index and the other family-background and peer-level variables mentioned in the main text in this section.

Figure 16. Effect of having a parent in STEM on the (predicted) probability of having career aspirations in STEM and ICT – Multilevel model



Source: Own estimations using PISA 2018 Microdata. The graph shows how the predicted probability of having career aspirations in STEM (left panel) or ICT (right panel) changes depending on whether students have/have not a parent in STEM. The model for STEM includes all EU27 Member States and the UK. The model for ICT includes 13 Member States and the UK.

6.2.4 Model 4: The effect of school-level variables on career aspirations in STEM and ICT

Finally, in the last model, we added three school level variables available in the OECD PISA microdata:

- **Disciplinary climate**: This index is constructed from students' answers to the question of how often the following things happen in their language-of-instruction lessons: "Students don't listen to what the teacher says"; "There is noise and disorder"; "The teacher has to wait a long time for students to quiet down"; "Students cannot work well"; and "Students don't start working for a long time after the lesson begins". The index is a general measure of the quality of teaching. Positive values of the scale mean that the student enjoys a better climate for learning than the average student in OECD countries.
- **Teacher support** is an index constructed from two variables in OECD PISA. One variable indicates that the student perceives that the "teacher helps students with their learning" and the other variable indicates the student's perception that "The teacher continues teaching until the students understand". Positive values on this scale mean that students perceived their teacher to be more supportive than did the average student across OECD countries.
- **Career guidance**: In schools where some career guidance is provided, principals were asked whether the career guidance is sought voluntarily by students or is formally scheduled into students' time at school.

These variables were not presented in the descriptive analysis, as no relevant association was found between boys' and girls' career aspirations and the values of these variables. The econometric results confirm that these variables do not seem associated with the development of career aspirations in STEM or ICT subjects. A possible reason for the lack of association is that these variables are only vague proxies for the school-level factors identified in the conceptual framework. Country-level variables

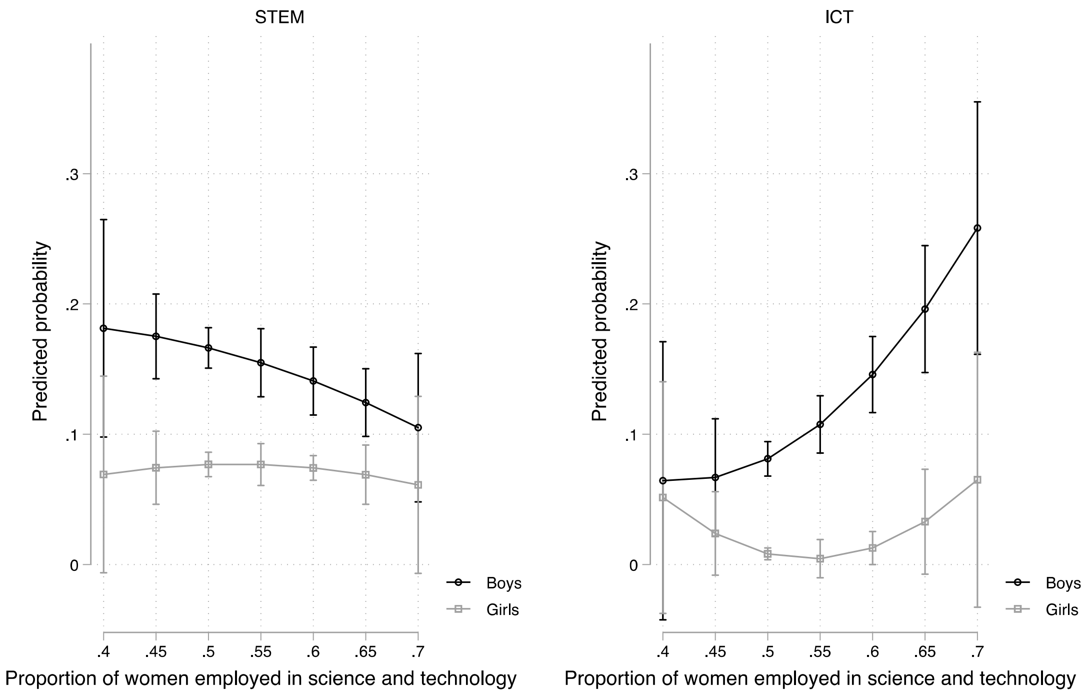
6.3 The effect of country-level variables on the models

This section discusses the effect of country-level variables, as analysed in the multi-level models.

6.3.1 Does more gender equality in the labour market for scientific profession decrease the gender gap in aspirations to STEM and ICT professions?

We use the results of the multilevel models to explore whether more favourable labour market conditions for women in STEM may foster girls' career aspirations in STEM and ICT, and hence narrow the gender gap in aspirations. We proxy gender equality in the labour market for STEM with the proportion of women employed in science and technology in each country. Figure 17 shows that countries where it is more common for women to work in the STEM sector also have smaller predicted gender differences in STEM career aspirations. This result suggests that in contexts where it is not unusual for a woman to be employed in the STEM sector, it is probably easier for girls to develop an interest in STEM. For ICT, instead, the gender gap in aspirations seems to widen with a higher proportion of women in science and technology in a country.

Figure 17. Effect of employment of women in science and technology on the (predicted) probability of having career aspirations in STEM and ICT

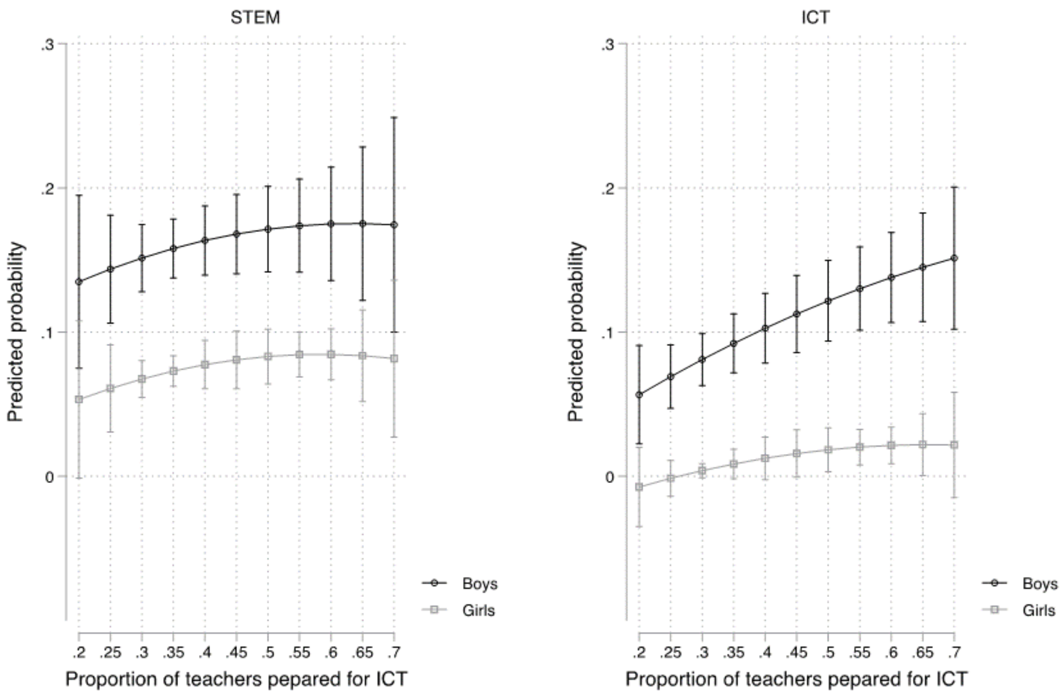


Source: Own estimations using PISA 2018 Microdata. The graph shows how the predicted probability of having career aspirations in STEM (left panel) or ICT (right panel) changes when the proportion of women employed in science and technology in a country changes. The model for STEM includes all EU27 Member States and the UK. The model for ICT includes 13 Member States and the UK.

6.3.2 Do teachers with better digital competence foster a more equal development of career aspirations in STEM and ICT?

In this section we ask whether teachers with better digital competence have an impact on the development of girls' and boys' STEM/ICT career aspirations. Figure 18 shows that, while there is no effect on the gender differences in STEM career aspirations, the differences in ICT career aspirations widens with more teachers with good digital competence in a country. The larger gap is driven by a stronger effect of teachers with digital competence on boys rather than girls.

Figure 18. Effect of teachers' digital competence on the (predicted) of developing career aspirations in STEM and ICT

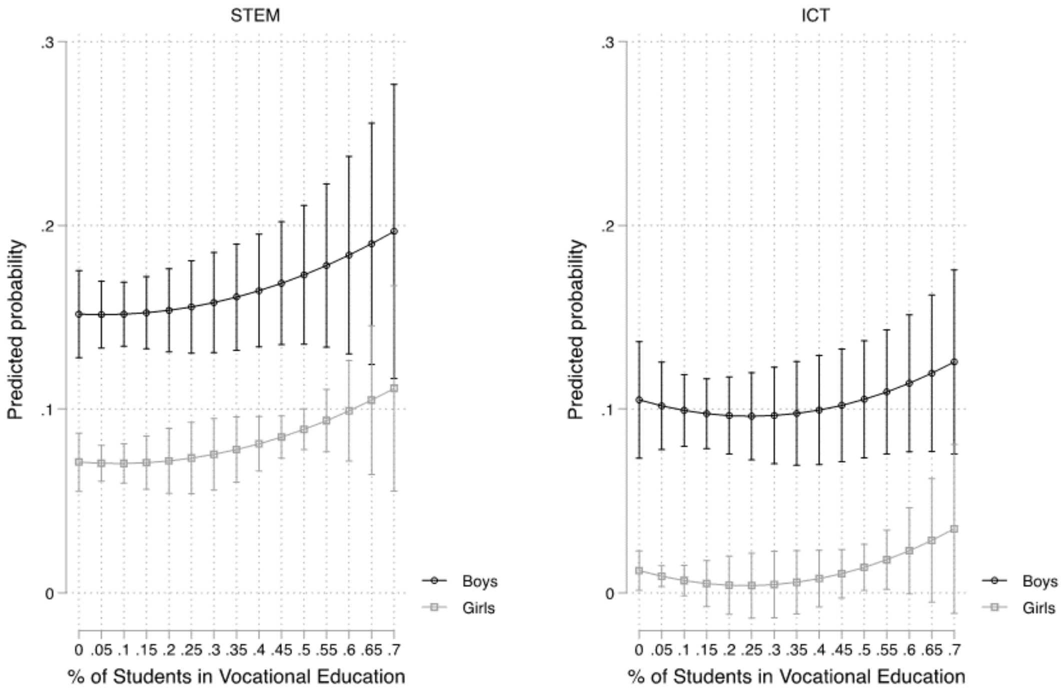


Source: Own estimations using PISA 2018 Microdata. The graph shows how the predicted probability of having career aspirations in STEM (left panel) or ICT (right panel) changes when the proportion of teachers who are (well) prepared for ICT changes. The model for STEM includes all EU27 Member States and the UK. The model for ICT includes 13 Member States and the UK.

6.3.3 Does the type of educational system play a role in shaping boys and girls interests in STEM and ICT?

Finally, we explore whether the degree of vocational orientation of an educational system widens or perpetuates gender differences in career aspirations. As a proxy for vocational orientation in school systems, we use the percentage of students in vocational education (computed from PISA microdata). As shown in 0, vocational system do not affect the gap in aspirations both in STEM and ICT.

Figure 19. Effect of vocational education system on the (predicted) probability of having career aspirations in STEM



Source: Own estimations using PISA 2018 Microdata. The graph shows how the predicted probability of having career aspirations in STEM (left panel) or ICT (right panel) changes when the percentage of students in vocational education changes. The model for STEM includes all EU27 Member States and the UK. The model for ICT includes 13 Member States and the UK.

7 Conclusions

7.1 Discussion of statistical results by study question

This section discusses the findings of the statistical analysis and uses them to answer the first two study questions, on the differences in girls' aspirations across countries and on the drivers and deterrents of girls' career aspirations in STEM professions. The third study question asks for policy conclusions from the findings and is discussed in the next section.

7.1.1 SQ1: Are there differences among countries regarding girls' career aspirations, and what explanations can be provided for these differences?

Our descriptive analysis shows that in all EU27 Member States girls are less likely than boys to aspire to STEM or ICT professions, while they are more interested than boys in healthcare professions. Throughout the analysis, ICT and STEM aspirations appear to follow different patterns. Countries with large gender differences in terms of career aspirations in STEM tend to have small gender gaps in ICT aspirations and vice-versa. Specifically, countries with a long tradition of STEM teaching at school (e.g., Central and Eastern European EU Member States) tend to have small gender differences in STEM aspirations, but large differences in ICT aspirations. Those countries with smaller gaps tend to be in Western European Member States which could be characterised as having large and growing demands for ICT workers.

The causes of the differences between girls' and boys' career aspirations in STEM, ICT and healthcare professions are widely explored in the research literature though there are few studies which examine country differences and factors in our model which might explain them. Some factors are ruled out by the evidence, such as system characteristics (tracking, single sex education) and some have mixed evidence, such as a gender biased culture. STEM parental occupation is a strong factor distinguishing OECD defined developed countries from others.

Some studies show at this may relate to the way STEM subjects are taught in school. Traditional textbooks tend to describe STEM subjects in a way that motivates more boys' than girls' interest. Studies have found that girls are more interested in knowing how a subject or a profession can benefit society and, for this reason, they can more easily see the social value of life-science or healthcare professions rather than STEM professions more broadly.

7.1.2 SQ2: What are the main determinants and deterrents of girls' career aspirations in STEM and ICT?

The analysis of drivers and deterrents of girls' career aspirations has followed the conceptual framework of the Social-Cognitive-Career Theory (SCCT). According to the SCCT the two main cognitive factors that drive adolescents' career aspirations in STEM are:

- **STEM self-efficacy**: individual self-belief to be able to succeed in STEM subjects in school and later in career in STEM
- **STEM outcome beliefs:** individual beliefs in the chance to succeed in STEM subjects and careers.

These two cognitive factors are mediated by two main orders of factors:

- **STEM learning experiences**: exposure to STEM subjects at school, in the family, in the group of peers
- **Contextual factors**: socio-cultural factors or social beliefs that adolescents can interiorise through the interaction with their group of peers, teachers, family.

Our statistical analysis has used proxies for the main drivers hypothesised in the conceptual framework and tried to identify whether differences in the factors postulated by SCCT can explain the observed differences in STEM / ICT career aspirations between boys and girls. The results of the statistical analysis are summarised below and contrasted with the hypotheses of the SCCT and the results of the data analysis and the literature review.

STEM learning experiences: The SCCT postulates that early exposure to STEM is the first step to developing STEM interests, self-efficacy, and motivation. There is no cross-country study focusing on the effect of exposure to STEM professions for the development of career interests. However, there is abundant evidence at the country-level pointing to the beneficial effect of some types of exposure, e.g., job shadowing or on-site visits. The literature also emphasises the relevance of informal exposure within the family, e.g., through parents who encourage their children's STEM interests. Most literature does not focus specifically on girls or gender differences. However, if exposure is an important determinant of STEM interests, it is natural to expect that different degrees of exposure for girls and boys may drive differences in career interests. The results of our statistical analysis are not at odds with this hypothesis. We find that girls participate less often than boys in on-site visits or job-shadowing and receive career counselling less often than boys. The data do not allow assessment of whether this lack of exposure is due to girls' preferences or scarcity of opportunities. However, this lack of exposure could be a driver of the different career aspirations by gender.

Regarding learning experiences within the family, we find robust evidence from the statistical analysis and the literature that parental profession (parents in STEM) is a strong predictor of both girls' and boys' preference for STEM, but the effect is larger for boys which may reflect that fathers are more likely to be role models than mothers. This indicates that learning experiences in the family are important for girls but may not be enough to drive girls' career aspirations in STEM further and that parents may perpetuate gender stereotypes in career choices.

The PISA data do not allow controlling for specific STEM learning experiences in the classroom, but only for more general proxies of quality of teaching, e.g., teachers' support, disciplinary climate, and the presence of career counselling in the school. None of these variables is found to significantly affects STEM/ICT career aspirations or the gender differences in aspirations between boys and girls although the research literature has examples where teachers and career counselling have made a difference to girls' aspirations.

Motivation and self-efficacy: The SCCT hypothesises that self-efficacy is the main driver of career aspirations. The psychological literature provides strong evidence of the positive effect of adolescents' self-efficacy on career choices. Self-efficacy is also thought to be influenced by individuals' level of competitiveness, which some studies have shown to be lower for girls than for boys. Our empirical analysis is in line with the literature, in that it shows that the degree of individual motivation (proxied by the "motivation to master goals" and the "value of school" indexes in PISA 2018) is an important determinant of career aspirations for girls in STEM and ICT. However, the effect of these motivational variables is stronger for boys than for girls.

School performance: Based on the SCCT, school performance is a consequence of learning experiences. Positive learning experiences help adolescents feel familiar with STEM subjects, motivate them to study and hence positively affect performance in STEM subjects. Good school performance, in turn, reinforces self-beliefs and motivation and leads to the development of career aspirations in STEM. The research literature supports the hypothesis that girls and boys choose careers that better match their school performance and cognitive skills. There are gender differences however in competitiveness with boys aspiring to STEM being more competitive than girls while girls are more motivated as well as evidence from elsewhere that girls increase their confidence in STEM through activities, such as mentoring, focused on them. Based on our econometric results, school performance is the strongest driver of career aspirations though the effect of science competences on STEM and ICT career aspirations in stronger for boys than for girls. This happens although girls, in particular those with STEM career aspirations, perform better in science than boys on average in the EU27. This indicates that girls with slightly lower science competences are not as driven to STEM and ICT careers as boys with similar competences.

Contextual factors: According to the SCCT, several contextual factors may shape adolescents' career interests. **Cultural factors** are important, as adolescents may interiorise social beliefs (e.g., gender stereotypes) from their family and their teachers which drive their career preferences. The **group of peers** can be a vehicle for these stereotypes too, especially among adolescents, who tend to identify themselves with their year groups. **Family socio-economic background** can influence the expectations students' have to be able to pursue a given educational career. The literature review confirm the importance of some of these contextual factors. The influence of peers has been linked in the literature with STEM performance, but not directly with STEM or ICT aspirations. The statistical analysis suggests that girls who are interested in a STEM career feel a lower sense of belonging to their group of peers than other girls. The stronger evidence from the econometric analysis indicates no effect for girls, suggesting that the descriptive result might be capturing other factors (e.g., cultural context) that influence both the sense of belonging and STEM aspirations. There is evidence from the econometric analysis that having a parent in a STEM occupation has a positive effect on girls' aspirations but this is less than for boys.

On other contextual factors the analysis finds evidence that in countries with a higher female employment rate in science and technology, the gap in STEM and ICT career aspirations is smaller. This suggests that in contexts where there are more women employed in science and technology, girls might not perceive STEM professions as unusual. However, the degree of gender equality in a country seems to be weakly linked to gender differences in access to STEM and ICT professions.

7.2 Policy pointers

The conclusions carry relevant policy implications. Our results can identify initiatives that are more and less likely to be beneficial in reducing the gap in STEM and ICT aspirations. Two key theoretical drivers of career aspirations, i.e., science performance and motivational factors, are shown to have an effect on both boys' and girls' career aspirations, but their effect is stronger for boys than for girls. This should be rectified. The evidence also shows that girls who prefer STEM careers are in general more motivated and have better science competences than boys while boys with lower science competences are more motivated than equivalent girls. This should be rectified.

It follows that policies aiming at reducing the gap in STEM aspirations and participation should not focus on (or not only on) improving science performance or motivation among girls. Policy initiatives should rather aim at building a stronger link between individual factors and the choice of a STEM or ICT career for girls. These initiatives can be promoted at the EU, Member State and school level, and are illustrated below.

The policy pointers also reflect on the availability of material in the research literature and the extent that this has been able and less able to address the research questions.

7.2.1 EU-level

Possible policy initiatives at the EU level are:

- Promotion of **in-depth research at the country-level** which focuses on so-far less explored cultural and institutional barriers of girls' aspirations and access to STEM and ICT, such as curriculum content, role models and the organisation of the science curriculum through compulsory education. This research should highlight examples of good practices and their applicability in other Member States, which can provide evidence for the formulation of targeted policy recommendations.
- Funding of process and impact evaluations of pilot initiatives which address the barriers to girls' aspirations and access to STEM and ICT applied in a sample of Member States. This research would establish which initiatives work effectively and how best to implement them.
- Use of existing EU funding programmes to **finance initiatives at the Member State level** to improve girls' perceptions of STEM and mitigate the influence of stereotypes. For example, the Girls4STEM pilot[128], financed through the Erasmus+ programme, focused on the dissemination of gender diversity and awareness raising material for teachers, to help them boost gender diversity in STEM teaching.
- Direction of HORIZON 2020 programmes and projects towards participating in school visits and events in Member States to promote careers for girls in STEM with female role models.
- Organisation of **awareness-raising campaigns** or the support of awareness-raising initiatives at the Member State level that aim at conveying a more gender-diverse image of STEM professions and contribute to inform girls throughout their compulsory education about the wide range of professional opportunities available in the STEM field and the wide range of requirements for entry.

7.2.2 System and school level

Member States and other authorities responsible for education systems can adopt policies and initiatives that reinforce those above which could be taken forward at the EU-level, and work in close cooperation with schools on their design and implementation. These could include establishing sustainable initiatives which are known to work, supporting the evaluation of pilots and the sharing of results, and promoting STEM and ICT careers to girls.

In addition, possible policy initiatives could include:

- Introduce mandatory **career counselling** for all schools, and, if needed, promote targeted career counselling for girls to inform them about the wide variety of STEM and ICT professions.
- Ensure career information, advice and guidance within early years and primary education challenges occupational stereotypes which some children have inculcated from an early age and promotes careers in STEM and ICT and the educational pathways to achieving them.
- Make **gender-sensitive training part of teachers'** and career **counsellors' training**. This is important to avoid teachers and counsellors (consciously or

[128] https://www.gender4stem-project.eu/

unconsciously) conveying their stereotypical beliefs to students. This is also particularly relevant in light of the gender-biased influence of parents on girls' STEM aspirations. Gender-sensitive training should be offered to teachers and counsellors in schools as part of their continuing professional development.

- **Foster cooperation between schools and organisations in the public and private sectors** to increase girls' exposure to STEM and ICT jobs, e.g., through on-site or virtual visits and job-shadowing opportunities. These initiatives should be targeted specifically to girls, because they tend to be considerably less exposed to these career opportunities than boys.
- **Support school initiatives to increase exposure to female STEM role models**, through the organisation of school-events where female STEM professionals or students are invited to talk about their professions or studies. If males are included, there should always be gender equality in numbers. These interventions have been shown to be effective, not only in spurring girls' interests in STEM, but also to mitigate gender stereotypes among boys, with potential peer-level spill-over effects.
- Provide **guidelines to schools on the use of textbooks** and other resources that teach STEM and ICT subjects in a more gender-diverse way, i.e., providing equal numbers of female and male role models, matching boys' stereotypical interests with those of girls', e.g., through examples of applications of science and technology to life-science and climate change, or that promote the creativity of STEM subjects.

Annexes: Full statistical results

The full results of the statistical analysis are provided separately as an Annex to this final report. They include:

- Annex I: Excel files with full descriptive statistics
- Annex II: Additional results from the econometric models

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