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Viarengo, Martina

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E-mail: eac-unite-a4@ec.europa.eu

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Gender Gaps in Education: Evidence and Policy Implication *

Viarengo, Martina

(The Graduate Institute, Geneva and Harvard University, Center for International Development)

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Results at a glance

The gender gap in educational attainment has not merely closed but has reversed in tertiary education in the majority of the EU's 27 member states and in other advanced economies.

However, significant gender gaps remain across fields of study and in science, technology, engineering and mathematics (STEM). Gender gaps in educational choices emerge early in secondary schooling, and then widen along the educational trajectory. Existing research provides evidence of a complex set of determinants, though the magnitude of the effects varies across countries and over time. Given the nature and magnitude of these gender gaps, and the fact that they vary by educational stage, different policies and interventions are needed along the educational trajectory.

Executive summary

This report focuses on gender gaps in educational attainment and educational trajectories. It provides a review of recent research and state-of-the-art empirical evidence by examining the economic literature. It documents trends and how gender gaps vary by level of educational attainment and field of study.

Existing research has documented the presence of limited gender gaps at the early stages of education. Gender gaps seem to be related to educational choices that start in high school, and then widen along the educational trajectory. This report shows that gender differences in educational choices are significant and persist over time. It also highlights the heterogeneity in gender gaps in STEM and across related sub-fields. Women are not equally under-represented in all sub-fields of STEM, yet are especially under-represented in the maths-intensive STEM fields. The available evidence suggests that the cross-country variation in gender differences in each STEM sub-field is as important as the cross-country variation in the overall STEM field.

Existing studies provide evidence of a complex set of factors that explain the observed gender gaps, though the magnitude of the determinants differs across countries and over time. Among other explanatory factors, the educational context, the structure of the labour market and the environment of the workplace, as well as broader gender equality in cultural values and social norms in society, appear to play major roles. In view of the nature and magnitude of today's gender gaps, and the fact that they vary by educational stage, different policies and interventions are needed along the educational trajectory. The current evidence on the effectiveness of policies and interventions converges toward showing the importance of teachers and role models.

Aperçu des résultats

L'écart de niveau d'éducation entre les femmes et les hommes ne s'est pas seulement réduit mais inversé dans l'enseignement supérieur dans la majorité des 27 États membres de l'Union européenne et dans d'autres économies avancées.

Toutefois, d'importants écarts entre les genres persistent dans certains domaines d'études, y compris les sciences, les technologies, l'ingénierie et les mathématiques (STIM). Les différences de choix éducatifs entre les femmes et les hommes apparaissent dès le début de l'enseignement secondaire, puis se creusent tout au long du parcours scolaire. Les recherches existantes mettent en évidence un ensemble complexe de facteurs déterminants, bien que l'ampleur de leurs effets varie selon les pays et dans le temps. Étant donné la nature et l'ampleur de ces écarts entre les genres et le fait qu'ils varient en fonction du niveau d'éducation, il convient de mettre en place des politiques et interventions différentes tout au long du parcours scolaire.

Résumé

Le présent rapport met l'accent sur les écarts de niveau d'éducation et de parcours scolaire entre les femmes et les hommes. Il passe en revue les recherches et les données probantes empiriques les plus récentes en examinant la littérature économique. Il documente les tendances et la façon dont les écarts entre les genres varient en fonction du niveau d'éducation et du domaine d'étude.

Les recherches existantes ont mis en évidence la présence d'écarts limités entre les genres aux premiers stades de l'enseignement. Les écarts semblent être liés aux choix éducatifs qui commencent au collège, puis se creusent tout au long du parcours scolaire. Le présent rapport montre que les différences des choix éducatifs des femmes et des hommes sont significatives et persistent dans le temps. Il souligne également l'hétérogénéité des écarts entre les genres dans les STIM et dans les sous-domaines apparentés. Si les femmes ne sont pas sous-représentées dans tous les domaines des STIM, elles le sont particulièrement dans les domaines des STIM à forte composante mathématique. Les données disponibles suggèrent que la variation entre pays des différences de genre dans chaque sous-domaine des STIM est aussi importante que la variation entre pays dans les STIM en général.

Les études existantes démontrent l'existence d'un ensemble complexe de facteurs qui expliquent les écarts de genre observés, même si l'ampleur des déterminants varie selon les pays et dans le temps. Plusieurs facteurs explicatifs semblent jouer un rôle majeur, notamment le contexte éducatif, la structure du marché du travail et l'environnement de travail, mais également la présence d'une plus grande égalité entre les genres dans les valeurs culturelles et les normes sociales de la société. Au vu de la nature et de l'ampleur de ces écarts entre les genres et du fait qu'ils varient en fonction du niveau d'éducation, il convient de mettre en place des politiques et interventions différentes tout au long du parcours scolaire. Les données probantes actuelles sur l'efficacité des politiques et des interventions convergent pour montrer l'importance du corps enseignant et des personnes servant de modèles.

Die Ergebnisse im Überblick

Das Geschlechtergefälle im Bereich der Bildungsabschlüsse ist zwar nicht einfach verschwunden, hat sich aber in der Hochschulbildung in den meisten 27 EU-Mitgliedstaaten und in anderen Industrieländern umgekehrt.

Gleichwohl verbleiben in einzelnen Studienfächern sowie in Wissenschaft, Technologie, Ingenieurwesen und Mathematik (MINT) erhebliche Geschlechtergefälle. Unterschiede zwischen den Geschlechtern bei der Bildungswahl zeigen sich schon früh in der Sekundarbildung und verstärken sich im Laufe des Bildungswegs. Die bestehende Forschung hat ein komplexes Gefüge entscheidender Faktoren ermittelt, obschon sich der Umfang der Auswirkungen zwischen den einzelnen Ländern und im Laufe der Zeit unterscheidet. Angesichts der Art und des Umfangs dieser Geschlechtergefälle und der Tatsache, dass Letztere je nach Bildungsphase voneinander abweichen, sind verschiedene Politiken und Maßnahmen im Laufe des Bildungswegs erforderlich.

Zusammenfassung

Schwerpunkt dieses Berichts sind Geschlechtergefälle im Bereich der Bildungsabschlüsse und -wege. Er enthält eine Neubewertung jüngster Forschung und spezifischer empirischer Daten durch Auswertung der Wirtschaftsliteratur. Aufgezeigt werden Trends und wie Geschlechtergefälle je nach Bildungsabschluss und Studienfach unterschiedlich ausfallen.

Die bestehende Forschung hat das Vorhandensein begrenzter Geschlechtergefälle in frühen Bildungsphasen dokumentiert. Geschlechtergefälle scheinen mit der Bildungswahl zusammenzuhängen, die im Gymnasium beginnt, und weiten sich im Laufe des Bildungswegs aus. In diesem Bericht wird veranschaulicht, dass Unterschiede zwischen den Geschlechtern bei der Bildungswahl erheblich sind und im Laufe der Zeit anhalten. Ebenso wird die Heterogenität von Geschlechtergefällen in MINT-Fächern und verwandten Teilbereichen dargelegt. Frauen sind zwar nicht in allen MINT-Teilbereichen im gleichen Maße, dafür aber insbesondere in den mathematiklastigen MINT-Fächern unterrepräsentiert. Die verfügbaren Belege legen nahe, dass die länderübergreifende Abweichung bei den Geschlechtergefällen in jedem MINT-Teilbereich so ausgeprägt ist wie die länderübergreifende Abweichung im allgemeinen MINT-Bereich.

Bestehende Studien enthalten komplexe Gefüge von Faktoren, mit denen sich die beobachteten Geschlechtergefälle erklären lassen, obschon sich das Ausmaß der entscheidenden Faktoren zwischen den einzelnen Ländern und im Laufe der Zeit unterscheidet. Unter anderen erklärenden Faktoren scheinen der Bildungskontext, die Struktur des Arbeitsmarkts und das Umfeld des Arbeitsplatzes sowie eine allgemeinere Gleichstellung der Geschlechter mit Blick auf kulturelle Werte und gesellschaftliche Normen wesentliche Rollen zu spielen. Angesichts der Art und des Umfangs heutiger Geschlechtergefälle und der Tatsache, dass Letztere je nach Bildungsphase voneinander abweichen, sind verschiedene Politiken und Maßnahmen im Laufe des Bildungswegs erforderlich. Die gegenwärtigen Belege für die Wirksamkeit von Politiken und Maßnahmen zeigen mehr und mehr, wie wichtig Lehrkräfte und Vorbilder sind.

1. Introduction

The aim of this report is to provide a review of the existing economic literature related to gender gaps in educational attainment and educational trajectories, focusing on academic research and state-of-the-art empirical evidence. The core studies presented in this review are drawn from recent research published in international peer-reviewed academic journals on the economics of education, labour economics and general interest economics, as well as from the main working paper series on economics. The coverage is mainly limited to member states of the EU. Section 2 presents stylised facts and trends concerning gender gaps in educational attainment, fields of study and learning outcomes. Section 3 discusses how gender differences emerge and develop along the educational trajectory. Section 4 reviews the evidence related to the role played by different factors in explaining the observed gender gaps. Section 5 discusses some policy initiatives and interventions for which there is consistent evidence about their effectiveness. Section 6 provides concluding remarks.

2. Gender gaps in education

2.1 Facts and trends

Women's level of educational achievement has increased over time, and the gender gap in educational attainment has not just closed but has reversed in many advanced economies. Figure 1 plots the highest level of completed education in the age group 25-34 by gender in 2019, the most recent year for which the data is available. On the left, panel A presents the educational attainment of the total population, the middle panel B provides these figures for men and on the right, panel C gives them for women. Men are over-represented at lower levels of educational attainment (i.e. at the upper secondary and post-secondary non-tertiary education levels and below), whereas the gender gap is reversed at the highest level of educational achievement. In the majority of the EU-27 countries, a larger share of women than men have completed tertiary education. On average among the member states, 45% of women have completed tertiary education vs 34% of men.

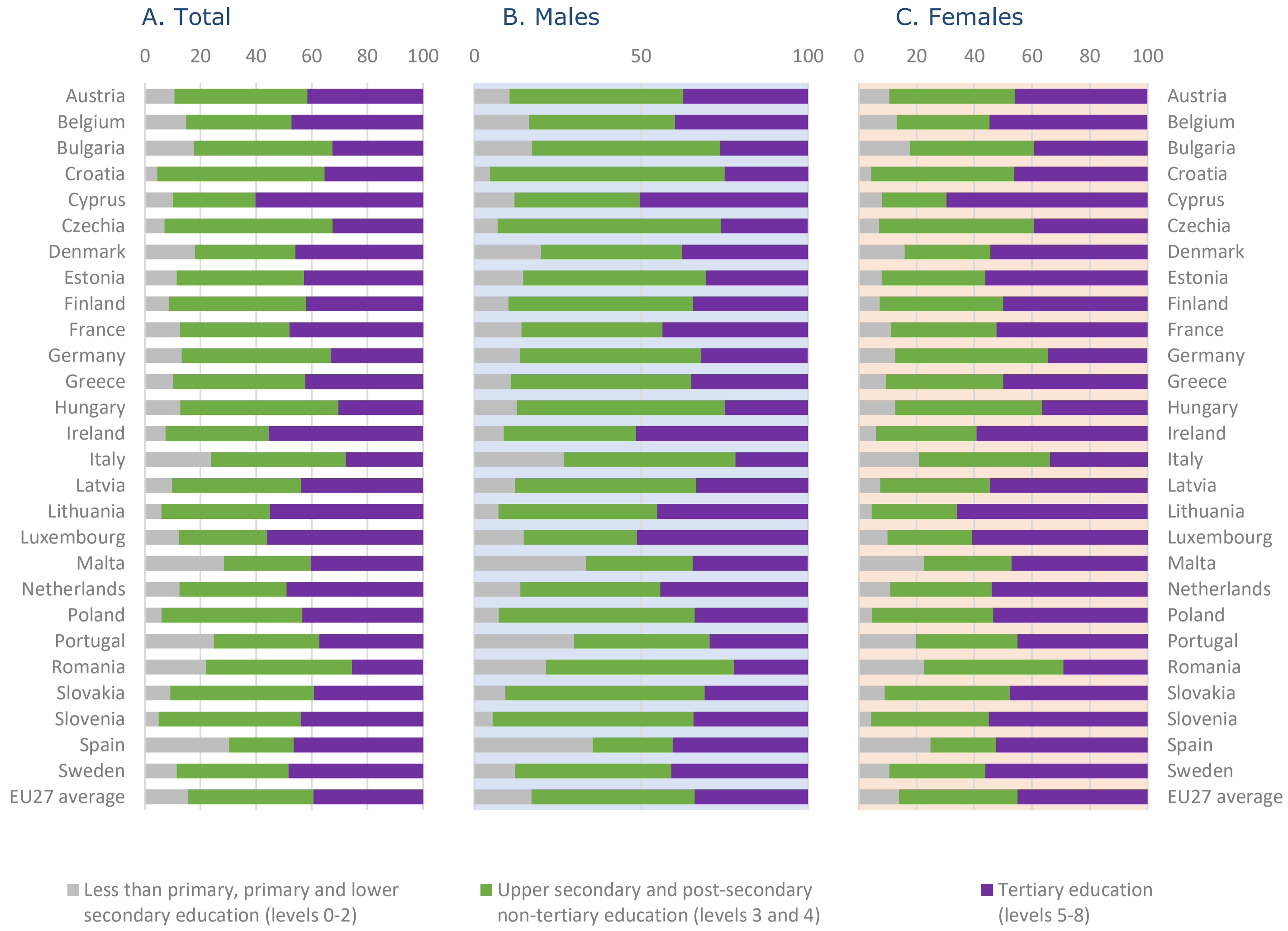
This so-called reversal of the gender gap in tertiary education, which has also been documented for other advanced economies such as the US (e.g. Goldin et al. 2006), is a relatively recent phenomenon in Europe. If we examine these gender gaps back in 2004, the gender gap in tertiary education already favoured women but by a much narrower margin. On average among the EU-27 countries, 28% of women and 23% of men had completed higher education.[2] If we look at these gaps in 2004 for an older age group, 25-64, we observe that the gap was slightly in favour of men (on average 21% of men completed tertiary education vs 20% of women).[3] In other words, the educational attainment has been steadily increasing for both genders, but at a faster pace for women.

The vast heterogeneity in the level of educational attainment across countries, as clearly shown in panel A of Figure 1, is echoed not only in levels for both genders (panels B and C, respectively), but also in changes over the past decades. In general, average levels of completed education are higher in Western European countries than in their Eastern European counterparts, though the gap has been closing. Meanwhile, gender equality in educational achievement is higher in the former-socialist Eastern European countries as well as in Nordic countries, and the reversal of the gender gap in tertiary education in favour of females is also more pronounced in these countries.

[2] The graph documenting this fact is available from the author upon request.

[3] The graph documenting this fact is also available from the author upon request.

Figure 1. *Level of educational attainment by gender, age group 25-34, 2019*



Source: Eurostat database.

Gender differences in educational choices are significant and persist over time. Figure 2 examines gender gaps in fields of study in tertiary education, and more specifically, at the bachelor's and doctoral levels respectively. Panel A shows the share of female graduates in each of six broad fields of study at the bachelor's (or equivalent) level across the EU's 27 member states in 2018, whereas panel B shows the corresponding numbers at the doctoral (or equivalent) level. The classification of fields of education is based on International Standard Classification of Education (ISCED) codes by UNESCO.[4]

Two general patterns in gender differences that are relatively homogenous in EU countries can be noted from Figure 2. First, the gender gap among the doctorate holders is much lower than at the bachelor's level, and is very small (or not significant) for the majority of countries in the EU. Second, there are significant gender differences by field of study. Women are on average over-represented in the fields of health, welfare, arts, humanities, social sciences and journalism, and are under-represented in STEM.[5] This pattern is consistent at the bachelor's, master's and doctoral levels,[6] and increases with the level of educational achievement.

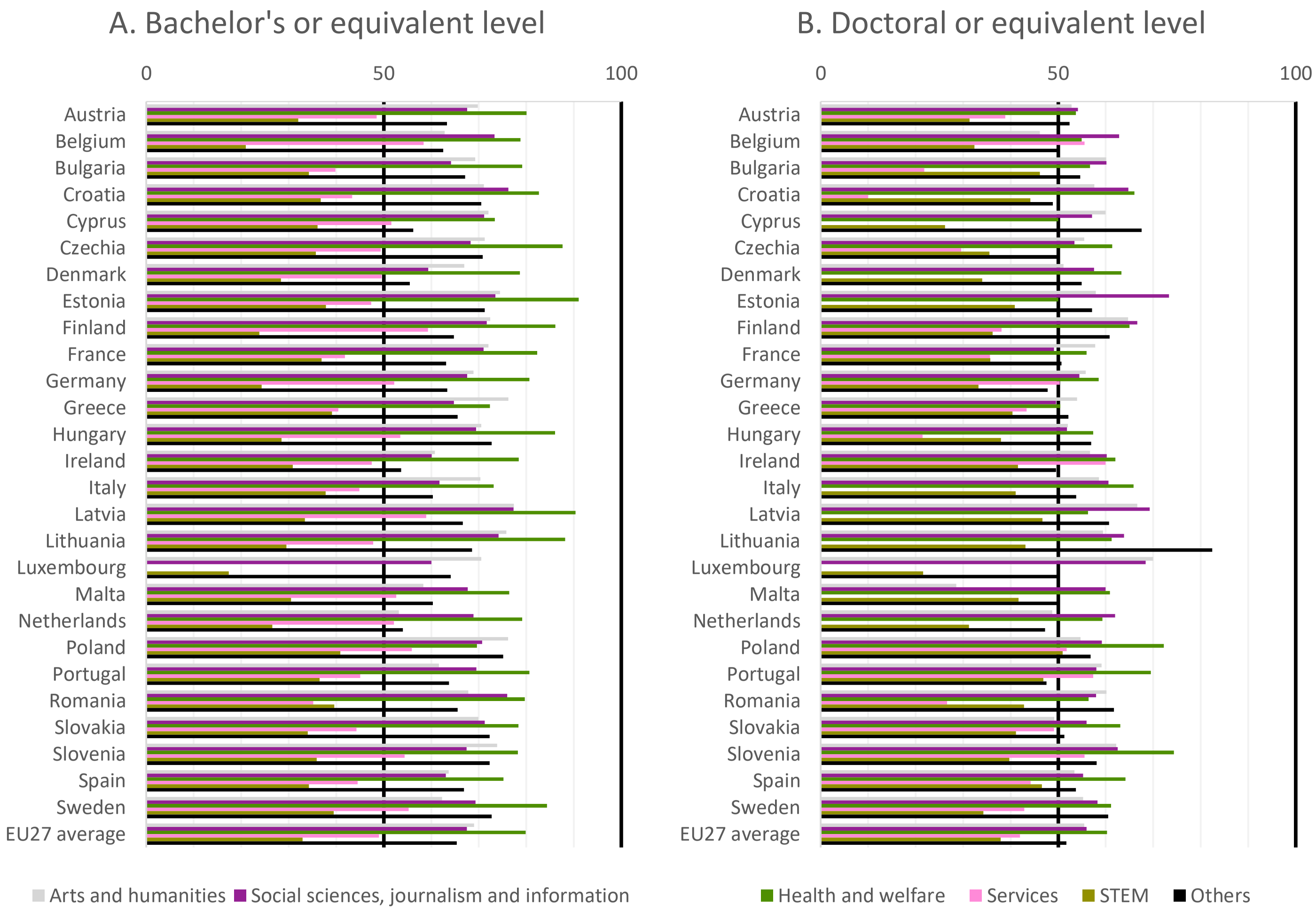
This persistent gender gap in STEM is more distinctly presented in Figure 3. Even if women are almost unanimously the minority in the STEM field at all educational levels in all 27 EU member states, there is a large heterogeneity among countries. Women on average represent 33% of STEM graduates in the EU-27, varying from the lowest shares of 17% in Luxembourg and 21% in Belgium to the highest of 39% in Sweden and about 40% in Romania. At the doctoral level, the EU-27 average share of women is 38%, ranging from 31% in Austria to 51% in Poland. Only one country, Poland, has achieved gender parity, though only at the doctoral level.

[4] The classification of fields of education is based on International Standard Classification of Education (ISCED) codes (F 2013 version) by UNESCO. Science, technology, engineering and mathematics (STEM) fields are coded as 05 (natural sciences, mathematics and statistics), 06 (information and communication technologies) and 07 (engineering, manufacturing and construction) in ISCED-F 2013.

[5] We define STEM according to the UNESCO classification. That is, science, technology, engineering, and mathematics (STEM) fields are coded as 05 (natural sciences, mathematics and statistics), 06 (information and communication technologies) and 07 (engineering, manufacturing and construction) in ISCED-F 2013.

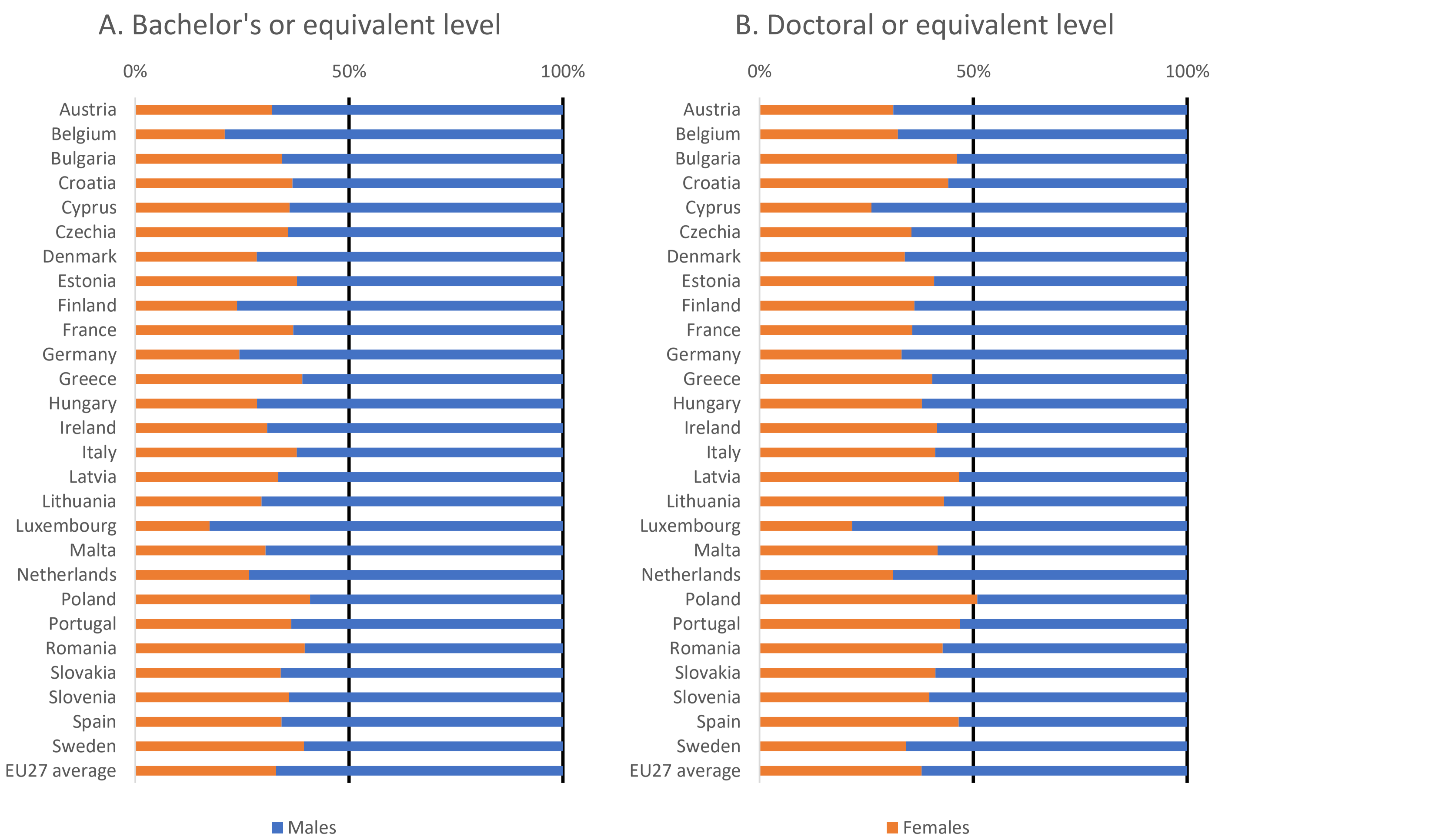
[6] The corresponding graph for the master's (or equivalent) level is available from the author upon request.

Figure 2. Share of female graduates by field of study, 2018



Source: Eurostat database.

Figure 3. STEM graduates by gender, 2018



Source: Eurostat database.

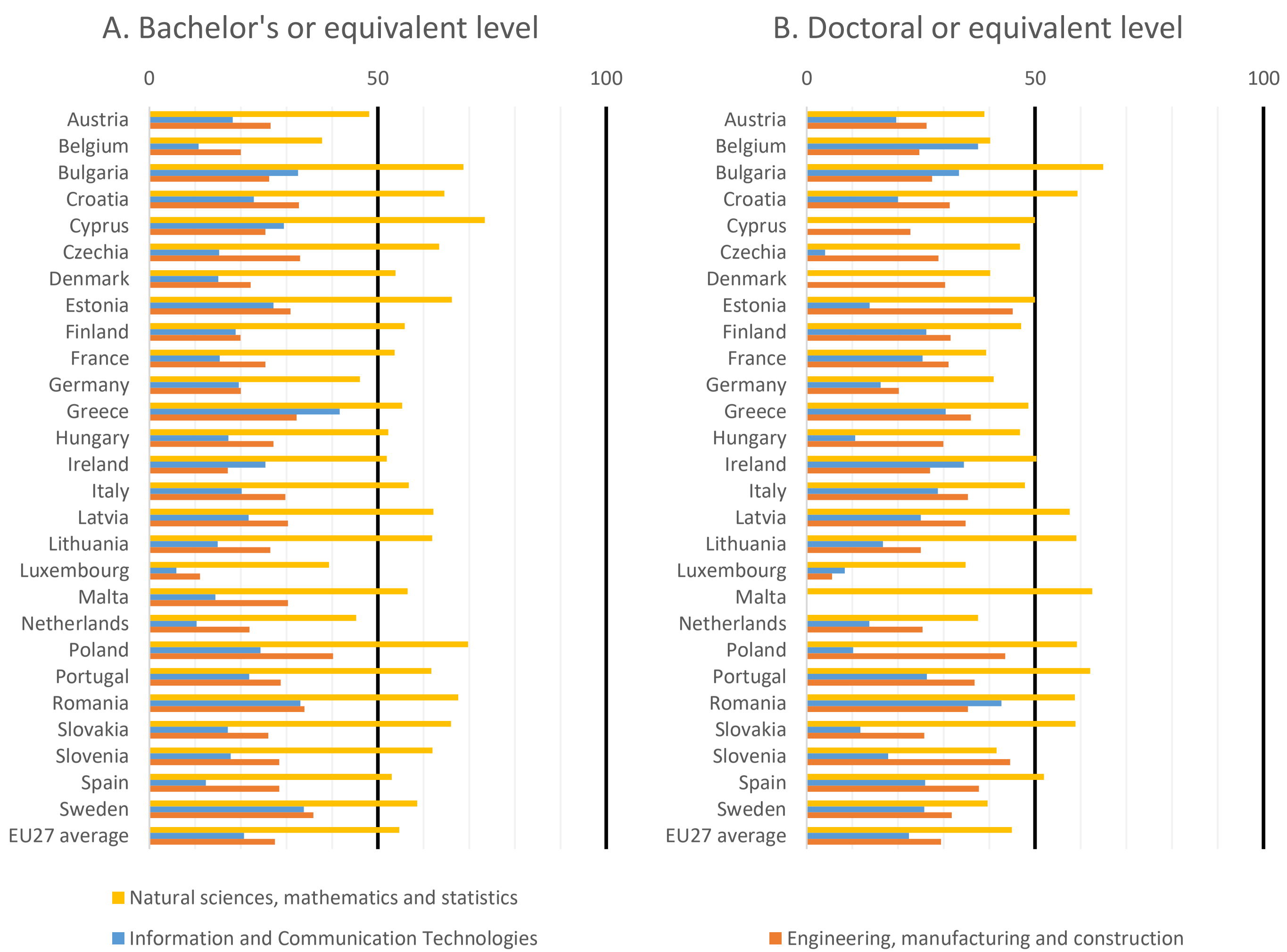
Figure 4 further explores the heterogeneity in gender gaps across sub-fields of STEM.[7] Women are not equally under-represented in all sub-fields of STEM. Specifically, the largest gender gaps are in the fields of information and communication technologies, engineering, manufacturing and construction. Women are especially under-represented in the maths-intensive STEM fields. On the other hand, in the field of natural sciences, mathematics and statistics, there is on average lower gender inequality at each level of educational attainment in tertiary education.[8] Moreover, an interesting pattern is apparent in the magnitude of the gender gaps in sub-fields of STEM in tertiary education and how they vary with the level of educational attainment. The share of women is inversely related to the level of educational attainment in natural sciences, mathematics and statistics, whereas it increases slightly in the other two sub-fields. It is also important to notice that the cross-country variation in gender differences in each STEM sub-field is as important as the cross-country variation in the overall STEM field.

To complement the previous stylised facts, Figure 5 shows the gender difference in cognitive achievement and learning outcomes in mathematics and science in compulsory education. Panel A plots the boy-vs-girl comparison at the fourth grade (a typical age of 9 or 10 years old), while panel B plots the gender gap at the eighth grade (a typical age of 13 or 14 years old), both from the 2019 TIMSS (Trends in International Mathematics and Science Study). TIMSS relies on a nationally representative sample of students who take tests to assess their cognitive ability and educational achievement in both mathematics and science. The test scores are standardised with a mean of 500 and a standard deviation of 100 during the first round, and subsequent rounds are linked to the first. Each dot in the plot represents the average level of test scores in one of the EU's member states. Green dots represent the country average test scores in mathematics, and yellow dots are the country average test scores in science. Dots above the 45º line indicate that boys have, on average, an advantage in learning outcomes over girls in the corresponding subject, while those below the 45º line indicate that the relative overall advantage lies with girls in that subject.

[7] As described earlier, these sub-fields follow the ISCED-F 2013 classification.

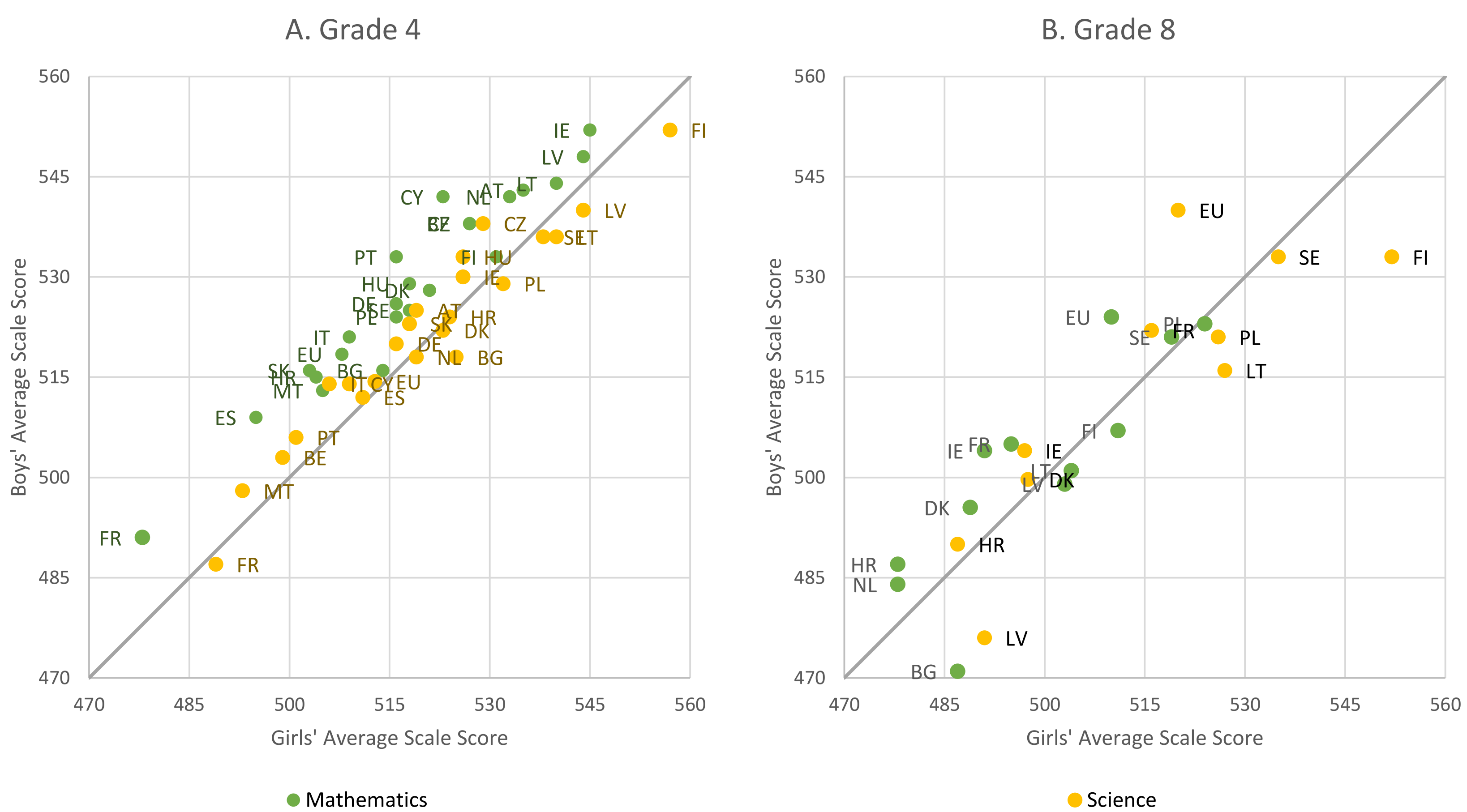
[8] Figure 4 shows these patterns at the bachelor's and doctoral levels. The corresponding graph at the master's (or equivalent) level is available from the author upon request.

Figure 4. Share of female graduates in STEM by field of study, 2018



Source: Eurostat database.

Figure 5. TIMSS achievement in mathematics and science by gender, 2019



Source: TIMSS 2019 (International Results in Mathematics and Science) dataset.

Figure 6 plots a similar graph for 15-year-old students (typically in the final year of lower secondary education) from the 2018 study by the Programme for International Student Assessment (PISA), with the additional purple dots representing test scores in reading. The aim of the PISA test is to assess the skills and capabilities acquired by students who are close to the end of compulsory education, and how they can use them in real-life situations. What these figures show is that the nature and magnitude of the gender gap varies in the different studies across countries and subjects. In general, there is a smaller gender gap in cognitive achievement in science and mathematics during the early stages of education (fourth grade). These gender gaps increase with the level of education and are larger in the eighth grade, with a greater dispersion of test scores among countries as well. What is more, the direction of the gap varies across countries. For instance, in Finland and Sweden the gender gap in the eighth grade is in favour of girls, while in Hungary and the Netherlands it is in favour of boys.

The increase in gender gaps in mathematics with the level of education has been documented in the literature (e.g. Kahn and Ginter 2017). Yet, the gender gap in test scores in reading favours girls in all the European countries that participated in the latest PISA study. Girls have higher test scores, and the magnitude of the advantage diverges across countries.

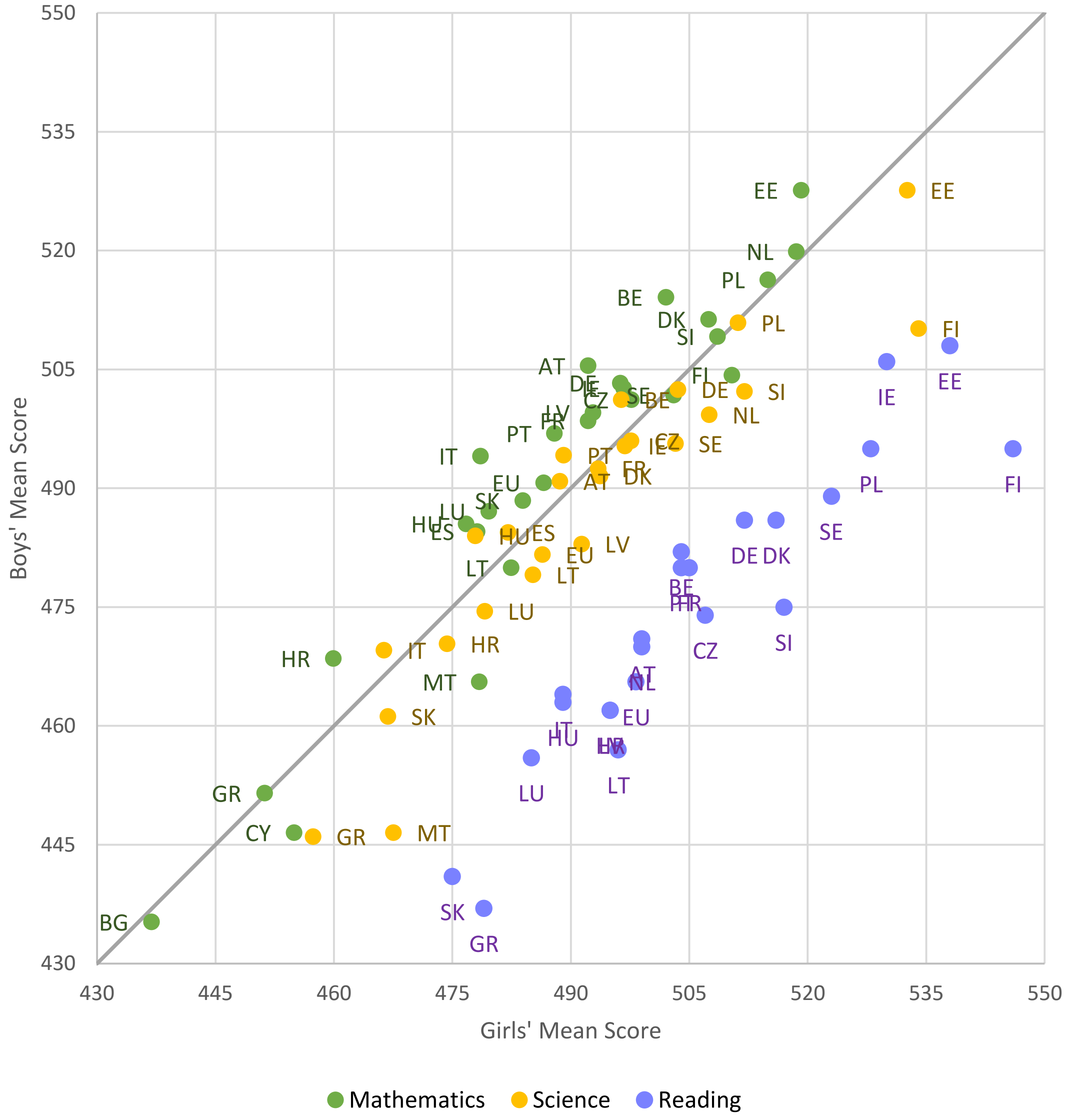
2.2 Education datasets

In this section we present an overview of the availability of datasets in education that provide the gender decomposition and cover the member states. Table A1 in the appendix provides a detailed description of each dataset, together with the country coverage and timeframe available.

Information on educational outcomes such as enrolment rates and attainment by field of study at the tertiary level in Europe is available by gender in several datasets. The OECD offers country-level aggregate data on these educational outcomes consolidating data from UNESCO, Eurostat and its own datasets.[9] Eurostat provides country-level data on the number of students enrolled by gender, type of institution and age group (early childhood education and primary education; lower secondary, upper secondary and post-secondary non-tertiary education; and tertiary education). For all 27 EU member states this data is available over 2012-18. For some countries data is available going back to 2005 and up to 2019. The field of study is aggregated into broader areas such as natural sciences, mathematics and statistics or information and communication technologies. Similar data related to graduation rates at the tertiary level by field of study and gender can be obtained from Eurostat for the same period. UNESCO provides the tertiary graduation rate by field of study only in an aggregate format for both genders, but data is available for a larger set of countries, including countries outside the EU-27. Both UNESCO and Eurostat offer gender-decomposed information on enrolment and educational attainment for primary and secondary education.

[9] See www.oecd-ilibrary.org/education/data/oecd-education-statistics_edu-data-en.

Figure 6. PISA achievement in mathematics, reading and science by gender, 2018



Source: PISA 2018 dataset.

Concerning data in the STEM fields,[10] the core data is available for the ISCED-F classification, with the related codes 05 (natural sciences, mathematics and statistics), 06 (information and communication technologies) and 07 (engineering, manufacturing and construction). For some selected years only, and for a few countries, the data from Eurostat[11] is available at a more disaggregated level of classification (i.e. data on computer use, code F0611, is available for a subset of countries between 2015 and 2018, but there is no data available for some other sub-components within the information and communication technology category). Even though sub-components of STEM are defined in the Eurostat dataset, the related data is not consistently available across sub-components, across countries or even at the aggregate level for the EU-27 or over time.

Data on learning outcomes is available for primary and secondary education by gender from the OECD and IEA (International Association for the Evaluation of Educational Achievement). The PISA study from the OECD offers information on learning outcomes in mathematics, science and reading for eighth-grade students by gender in participating countries. PISA was first conducted in 2000, and has been carried out every third year since then. For students in the fourth and eighth grades, IEA conducts the TIMSS, which offers information on learning outcomes in mathematics and science by gender. There have been seven waves of TIMSS since 1995, one wave every four years. TIMSS Advanced offers information on learning outcomes by gender for students undertaking advanced mathematics and physics classes in their final year of secondary school or at the start of their STEM coursework in universities. There are three waves of this study: 1995, 2008 and 2015. IEA offers information as well on computer literacy by gender for eighth-grade students in the International Computer and Information Literacy Study. There are two waves of this study: 2013 and 2018. Learning outcomes for fourth-grade students are available from IEA in the Progress in International Reading Literacy Study (PIRLS). It offers information on educational achievements in reading and has four waves, one every five years between 2001 and 2016.

On adult literacy, information is available by gender, but aggregated at the country level from Eurostat, UNESCO, the World Bank and the OECD. The OECD offers individual-level information on literacy outcomes, such as the ability to solve problems in technology-rich environments, and information on how skills are used at work and in other contexts in the Programme for the International Assessment of Adult Competencies (PIAAC).

Information by gender on tertiary enrolment rates and educational attainment in the field of artificial intelligence (AI) or sub-fields is not available for European countries. Using data from the Joint Research Centre of the European Commission, Zhang et al. (2021) document that in Europe most of the specialised AI courses are offered at the master's level, with some specialised bachelor's studies and very few Ph.D. programmes. The AI sub-fields of robotics and automation are most commonly found

[10] Source: www.eter-project.com/uploads/assets/pdf/ETERIII_handbook_running.pdf.

[11] See Eurostat EDUC_UOE_GRAD02 (https://europa.eu/!JM98Qu).

along master and bachelor's specialisations. Machine learning is most often offered as a short course.

3. Gender gaps in the educational trajectories

In the previous section we documented how gender gaps vary by level of educational attainment and field of study. In this section we will examine how gender gaps develop along the educational trajectory by also considering the role of educational choices. Existing research has shown the limited gender gaps at the early stages of education. Gender gaps seem to be related to educational choices that start in high school, and then widen along the educational trajectory.

The literature finds, in general, small gender differences in cognitive development and larger gender differences in language and behaviour, both favouring girls. Del Boca et al. (2019) review the literature examining the impact of early childcare on the short- to medium-run cognitive and non-cognitive development of children, and the long-run educational, labour market and life outcomes. The evidence in the literature is mixed. The evidence is also mixed when it comes to gender differences in the effects of early childhood intervention. Specifically, girls benefit more from interactions with adults during early childcare before the age of three, while boys encounter larger negative effects from formal childcare earlier than the age of twelve months.

Dietrichson et al. (2020) review studies on the long-term effects of universal preschool programmes for children under the age of six. Mixed effects are found, with variation across the effects on test scores and school grades, on health, well-being and behaviour. The effects are also heterogenous across preschool programmes and across countries. The majority of studies find that preschool programmes are more beneficial for students of low socioeconomic status. Still, these studies find that there is no clear difference in effects across genders.

Gender gaps seem to emerge in secondary education around the educational choices and along the related trajectories that boys and girls undertake. Rapoport and Thibout (2018) study the gender differences in educational choices. Besides the choice of principal subject in high school and in higher education (major), this paper expands the literature by including choices in high school curriculum (general, technical or vocational) and higher education pathway, which are characterised by the selectivity, competitiveness and the length of the programme. The study examines a sample of secondary school pupils in France. The authors address the possible endogeneity of test scores by using an approach involving earlier test scores as instrument variables for later test scores. The study finds that the educational choices in both high school and higher education are partly driven by pecuniary factors. That is, boys take future expected earnings into greater consideration compared with girls, when making decisions on educational choices. In high school, the marginal impact of test scores on educational choices is higher for boys than for girls, and consequently, the gender difference in educational choices is larger for pupils at the same level in mathematics and humanities. This means that boys attach greater importance than girls to their abilities in specific subjects as measured by test scores. Though also partly driven by test score, gender differences in choices regarding higher education are more closely related to gender differences in other factors. In particular, the authors refer to the possible role of tastes and social norms that may reinforce each other through interactions with peers, teachers and parents. However, this study does not allow the authors to identify the role of these factors or to disentangle them.

Kuhn and Wolter (2020) further examine gender differences in preferences concerning future employment opportunities. They take advantage of the dual-track apprenticeship education system of Switzerland and examine the task content of learnable occupations in the Swiss apprenticeship system. They document that male apprentices favour jobs that mainly involve creating or manipulating objects, or "things", while female apprentices, on the other hand, favour occupations that mainly involve interacting with customers, or "people". Simple statistical analysis at the occupational level indicates the high power of this "things vs people" dimension in explaining the gender segregation in occupation choice. Furthermore, estimations from a univariate regression using the individual-level data from surveying the young apprentices in the German-speaking part of the Swiss Canton of Bern echo the occupational-level results.

Kugler et al. (2021) study the determinants of choices of university majors. Using student-level administrative data for all fields from a large private university in the US, the authors examine the effects of factors such as grades, high school preparations, the gender composition of the faculty, gender composition of the peers and future returns to the chosen majors. Empirically, they estimate a dynamic logit model with standard errors clustered at the student level. Treating the choice of subject as a dynamic process is an important contribution of this paper. The estimation shows that, in general, male and female students are equally likely to switch out of a major as a response to poor grades in classes related to that major. Additionally, men are more likely than women to switch out of a female-dominated major in the case of low grades. Yet, women are more likely than men to switch out of a major only in the case of poor grades in a male-dominated and STEM major. In other words, exposure to more negative and unfavourable signals makes it more likely for women, compared with men, to switch out of a major.

Kahn and Ginther (2017) provide a review of the literature that focuses on gender gaps in the STEM disciplines. The authors emphasise that the gender differences concentrate in fields that are maths-intensive – geosciences, economics, engineering, maths, computer science and physical science. They then summarise findings from studies that show that the gender gap in mathematics test scores is small until it widens during the middle and high school stages. The authors then argue that these findings are consistent with explanations of gendered preferences, where females prefer jobs that are people-centred while males prefer jobs that are thing-oriented. They also acknowledge that other factors play an important role in the occupational choices of women. Among these, considerations related to work and family life balance – e.g. the lack of family-friendly policies and flexible work arrangements, as well as a "chilly climate"[12] – that are

[12] This is measured by the share of men in a given occupation.

associated with lower job satisfaction for women, play an important role in the occupational choices of women, and partly explain their under-representation in male-dominated occupations.

In economics, the discipline in the social sciences with the largest gender gaps among academics, Avilova and Goldin (2018) document that gender gaps already exist at the undergraduate level, and they widen along the educational pattern and subsequent professional career trajectory.

4. Determinants of gender gaps

The existing literature has examined the role of different factors and to what extent they contribute to the formation and development of gender gaps in educational attainment and segregation across fields of specialisation. The role of both biological differences and environmental conditions have been studied. Factors include family environment, educational context, role models, behavioural and psychological factors, preferences and culture. Freeman and Viarengo (2014) provide evidence on the school and family effects in a large sample of countries. Delaney and Devereux (2021) provide a comprehensive overview of these factors, and McNally (2020) presents a review of the studies centred on STEM. In this section the analysis will be limited to three factors: the structure of the education system, the structure of the labour market and the cultural environment.

4.1 Educational context

Educational environments matter. The characteristics of schooling systems and their institutional set-up play an important role in explaining variation in students' educational achievement and learning outcomes across countries (Woessmann 2016). Research has examined the role of institutional settings, the design of the curriculum, resources, teachers and peers.

This can be also seen in the case of the 27 EU member states, where the structure of the education system differs significantly from country to country. Specifically, education systems vary in important characteristics such as the relevance of general vs vocational education and training (VET), the organisation of the different education levels, and the framework and requirements for tertiary education.

Hanushek et al. (2017) also show that this institutional structure of schooling systems has long-lasting consequences over the professional life cycle. The authors examine whether gains in employment at younger ages from vocational education may be offset at a later stage of life, through reduced adaptability and thus a decreasing probability of employment. They adopt a difference-in-difference method to verify such a trade-off, using individual-level data for 11 countries from the International Adult Literacy Survey. The authors find an early advantage that is offset later over the life cycle. The estimated age of the shift in the relative advantage in employment is 49, meaning individuals with a general education background are more likely, on average, to be employed by the age of 49, compared with those who have vocational education. This pattern is more pronounced for countries with a greater emphasis on apprenticeship, namely Denmark, Germany and Switzerland.

In this regard, a key feature of the schooling systems, which varies significantly among countries, is the tracking system. Tracking refers to the practice of sorting students into different streams/schools (e.g. general education vs VET) according to their ability, at an early age (typically around age 10). A comprehensive system, by contrast, provides multidiscipline and wide-ranging education to all children universally.

Hanushek and Woessmann (2006) examine the effect of educational tracking on educational performance and educational equality. This study estimates the effects of this sorting in the educational institutions across countries through a difference-in-difference approach using data from TIMSS, PIRLS and PISA. The statistical model compares the difference in outcomes between primary and secondary education across the tracking education systems and non-tracking ones. The results consistently indicate that early tracking systems increase and widen the inequality in educational achievement, though the evidence is less conclusive regarding the negative effect on the level of performance.

4.2 Labour markets and educational choices

Even if gender gaps have not only closed but have reversed in tertiary education, and women's labour force participation has steadily increased, gender gaps in labour market outcomes persist in professional occupations (Ganguli et al. 2014; Petrongolo and Ronchi 2020). These gaps are particularly large in the higher paying occupations in the economy (Bertrand 2018). And this happens even in sectors, like the legal sector, where the gender gap in educational attainment has closed, there is no significant gender gap in academic performance and there is gender parity in entry-level positions; still, gender gaps increase with seniority (Ganguli et al. 2021). This is important because the characteristics of occupations (both pecuniary and non-pecuniary) and the perceptions that girls and boys have about different career paths affect their educational attainment and choice of field of study. That is, the labour market conditions of specific occupations – such as expected earnings and career progression, workplace flexibility and job security – affect decisions in education.

Wiswall and Zafar (2018) investigate the relationship between gender preferences for the workplace and gender choice of education fields and jobs. The authors survey undergraduate students at New York University with hypothetical questions on job choices. Gender differences exist in workplace preferences among these students. Males prefer jobs with higher growth rates in earnings, whereas females prefer more secure jobs and jobs with greater flexibility. Combined with the follow-up surveys four years later regarding the actual choices of majors and jobs, the authors estimate a strong and systematic link between job preferences and decisions in choosing majors and jobs, through a choice model. Specifically, the authors estimate that, for a university major, one standard deviation increase in the perceived probability of dismissal in future jobs drives 5% of women and 4% of men away from a major, and one standard deviation increase in the perceived average earnings from future jobs attracts 5% more women and 16% more men to a major. The authors also show that the within-field gender difference in jobs, compared with the gender difference in fields, drives the gender gap in earnings. Moreover, the aforementioned gender preferences in the workplace account for a quarter of the gender wage gap. This paper extends the literature on the importance of the non-pecuniary job attributes in the decisions on jobs and college majors.

Evidence on the importance of career prospects and non-pecuniary job characteristics in STEM has been found by Hunt (2016), who examines the gender difference in the exit rate for different fields of education during university studies. The author documents that more women, relative to men, leave science and engineering during college, compared with other fields. Using two waves of the National Survey of College Graduates data, the author estimates a difference-in-difference model comparing the gender difference in exit rates, namely the excess female exit rate, across three categories of fields – science and engineering, all non-science and non-engineering, and economics and finance – to explore the relevance of male dominance of a field measured by the male share in that field of study. The results suggest that the gap is driven by the field of engineering rather than science, and particularly by women's dissatisfaction with engineering jobs in terms of pay and promotion opportunities, accounting for more than half of the weight. Other factors proposed in the literature, such as work hours and workplace conditions, are found to be secondary to pay and promotion potential. Furthermore, the results suggest that the excess female exit rate in engineering is indeed similar to that in economics and financial management, which are also male dominated, after controlling for male dominance.

4.3 Cultural context

The role that cultural values and social norms in society play in contributing to gender gaps in educational attainment and gender segregation across fields of study has been documented in the literature. Cultural influences, social norms and existing gender stereotypes appear to be associated with larger gender gaps in education, with significant heterogeneity among countries. These studies have shown that the more liberal and egalitarian a society, the smaller the gender gap in learning outcomes in mathematics, suggesting that the gap is endogenous to social norms.

The role of country-level culture has been examined by Nollenberger et al. (2016), who study the relationship between culture and the gender gap in mathematics. The authors use four waves of PISA data, which provide culture-neutral maths assessment results for second-generation immigrants across 35 countries. An individual-level multivariate model regressing maths test scores on gender, culture and other controls estimates the relationship between culture and the maths gender gap. The results show that the gender gap in mathematics decreases for students with ancestry from countries with greater gender equality.

Rodríguez-Planas and Nollenberger (2018) examine the effect of gender-specific social norms on gender gaps, and more specifically whether the effect is limited to the field of mathematics. The authors use four waves of PISA data on 15-year-old immigrant students in nine host countries. The results of the empirical analysis show that the gender social norms from the country of ancestry have positive effects on the maths test scores of girls relative to boys, and the effects also expand to subjects other than mathematics. The authors find weak evidence indicating that the effects are driven by beliefs related to women's political empowerment and their economic opportunities. In other words, their findings suggest that gender norms affect the gender gap in test scores through general preference for mathematics, rather than altering particular stereotypes related to maths. Gender norms are related to cultural beliefs over the perceived role of women in society. The authors find that girls whose parents' country of ancestry is characterised by greater gender equality also have higher preferences for mathematics. In addition, these findings are mainly attributable to cognitive skills, with social gender norms affecting parents' expectations of girls' learning trajectories relative to boys.

Gevrek et al. (2020) also study the relationship between gender equality in society and the gender gaps in academic achievement and attitudes in mathematics. They rely on the 2012 PISA wave in 56 countries to investigate such relationships. They adopt a semiparametric Oaxaca-Blinder decomposition and then utilise cross-country variations in gender gaps in maths scores and attitudes. This two-stage approach is used to test the gender stratification hypothesis that societies with higher levels of gender equity have smaller gender gaps in academic achievement and attitudes in mathematics. The estimation finds a significant association between a smaller gender gap in wages and a smaller unexplained part of the gender gap in academic achievement in mathematics, supporting the gender stratification hypothesis. Nevertheless, as for the students' maths attitudes (which are measured in the 2012 wave of the PISA study in terms of maths self-efficacy, intrinsic motivation to learn maths and instrumental motivation to learn maths), the estimation yields mixed and inconclusive evidence for the gender stratification hypothesis.

5. Policies, reforms and interventions

In the previous sections we have documented how gender gaps in educational attainment and educational choices emerge and how they develop along the educational trajectory. We have also reviewed evidence related to the determinants of these gaps. In this regard, we have discussed the importance of the educational environment and the characteristics of occupations, as well as the role of cultural values and social norms in affecting educational attainment and the choice of field of study. Diverse policies, reforms and interventions have been introduced at different stages of the educational trajectory across member states. In this section, we look at teachers and role models – aspects for which there is consistent evidence about their effectiveness. Subsequently, the mixed evidence concerning the de-tracking reforms is discussed.

5.1 Teachers

Existing research has examined various characteristics of teachers, and how they affect educational achievement and learning outcomes. Two aspects have been central to recent research, which has examined the role of teachers' bias related to stereotypes and teachers of the same gender.

Recent studies have shown that girls perform worse when they are assigned to a biased teacher. Carlana (2019) examines the effect of teachers' stereotypes on the achievement of students. The author conducted a gender-science implicit association test (IAT) on 1,400 maths and literature teachers in northern Italy, linked with administrative data from the Italian authority and surveys on students to evaluate these effects. The field experiment shows a strong positive association between the gender stereotypes of maths teachers, as measured by the IAT, and the gender gap in students' achievement in maths. The effect is shown to stem, at least partially, from girls performing below their potential after being exposed to maths teachers with strong gender stereotypes (i.e. teachers having stronger pro-boy biases). These gender stereotypes are measured in terms of teachers' implicit association between boys and their performance in mathematics (e.g. 'boys are better at maths'). However, no effect has been found regarding exposure to literature teachers with gender stereotypes.

Terrier (2020) studies the effect of teachers' gender biases on the progress and schooling decisions of students. The author uses a student-level dataset covering 4,490 pupils from 35 middle schools (grades 6 to 11) in France. The author's empirical strategy relies on a difference-in-difference method, based on variations in the gender biases among teachers and the quasi-random assignment of students to these biased teachers. More specifically, the author examines the progress and schooling decisions of girls relative to boys enrolled in classes with more biased teachers, compared with the progress and schooling decisions of girls enrolled in those classes with less biased teachers. The results show that these gender-biased middle school teachers generally favour girls during the evaluations, and as a result, academic achievement is lower for boys compared with girls with similar conditions. In addition, the probability of choosing a science stream in high school also increases for girls who benefit from this gender bias in mathematics, and this probability is estimated to be approximately a 12% reduction in the gender gap in the number of students choosing the science streams.

The process of feminisation of the teaching profession, which has reached different levels across member states, at varying points in time, raises the question as to whether it has an effect on girls and boys' educational performance. The studies so far have provided mixed results. Holmlund and Sund (2008) address this research question and examine the role of teacher–student gender matches in affecting performance in tests. They find no evidence that a same-sex teacher leads to improved outcomes in student learning. Their empirical strategy consists of leveraging the turnover in teachers, from the perspective of a student, during the three-year upper secondary education in Sweden to estimate the effect of having a teacher of the same gender in the class grade of that student in the relevant subject. The authors note the potential endogeneity problem that arises from the fact that teachers are neither randomly assigned to students nor do they choose subjects randomly. They employ a within-student specification to control for the unobserved characteristics of students and the potentially endogenous assignment of teachers to students, as well as a within-subject specification to control for the teachers' potentially endogenous choices of subjects. In the context examined, the results show no effect of having a same-sex teacher on a student's grades.

Puhani (2018) studies the effect of teachers' gender on students' educational paths. The author focuses on tracking procedures in education, in the context of Hessen, Germany, where at the end of primary education pupils decide on the type or track they will undertake in their middle school education. The study uses administrative data from Hesse covering the whole population of relevant students and their teachers from 2007 to 2012. Two outcomes related to tracking are examined – teachers' recommendations of the tracking choice for each pupil at the end of primary school education and the actual track of middle school education followed by each student. A within-teacher model addresses the potential endogeneity. The empirical results suggest that teachers do not base their recommendations of middle school tracks on whether the pupil is of the same gender as the teacher, and students' tracking decisions are not affected by whether they were taught by a teacher of the same gender as themselves.

Lim and Meer (2020) evaluate the effects of teacher–student gender matches on the educational outcomes of students in the long run. They take advantage of the random assignment of students and teachers to classrooms each year in the middle school education system in South Korea. They use panel data covering middle schools in Seoul to perform the empirical estimation, using models with school-by-subject-by-ability-group fixed effects. The results suggest the presence of short-term effects of teacher–student gender matches. Specifically, girls score significantly higher in tests when they are taught by female teachers instead of male teachers, but boys score insignificantly lower when they are taught by female teachers instead of male teachers. Moreover, the authors show that these effects are persistent over time, up until high school. The authors also explore the effects of girls being taught by a female maths teacher. They find that girls taught by female teachers in maths at the seventh grade are more likely to attend better-quality high schools, to take more maths classes in high school and to choose a STEM major when applying for university.

5.2 Role models

The importance of role models has been shown in the existing research. This question is especially relevant in male-dominated fields, where given the current gender imbalance it is more difficult for women students to have a role model. In this context, Breda et al. (2020) provide evidence of aspirational effects in female STEM enrolment from external female role models. Their evidence comes from a large-scale field experiment of random classroom intervention in high schools in the Paris region. Tenth-grade students and science-track twelfth-grade students in the treated classrooms received exposure (one-hour) to female scientists. The authors estimate that this intervention increased the share of girls in the science track in twelfth-grade by 8%, from the baseline level of 29%. The effects are shown to be driven by girls shifting into STEM programmes that are male dominated such as maths, physics, computer science and engineering. These programmes offer better opportunities to get into prestigious graduate schools. At the same time, no effects are found either among science-stream twelfth-grade boys, nor among tenth-grade boys. The authors suggest that the underlying mechanism of the role model effect is aspiration through challenging and improving girls' perceptions of careers related to science by providing a full picture of such careers. This finding further highlights the important role of the learning environment in both primary and secondary school.

González-Pérez et al. (2020) examine the effects of a role model intervention consisting of professional female volunteers working in STEM talking to girls about their careers. The analytical sample includes 304 girls studying in one of the 16 Spanish schools that participated in the study, ranging from sixth primary grade (12-year-old) to fourth secondary grade (16-year-old) students. The intervention does not rely on the random allocation of girls to the female role model. The empirical strategy relies on a one-group pre-test/post-test design methodology, comparing girls' preferences before and after the intervention for the group of girls who participated in the study. Consequently, this experimental design does not allow for the rigorous identification of causal effects. The authors find that the role model intervention is associated with an improvement in girls' preferences for STEM. In particular, the exposure to women with successful professional and personal experience in STEM fields is associated with increases in girls' self-reported mathematics enjoyment, the importance they attach to maths and their beliefs that they can be successful in STEM fields, and thus raises their likelihood of choosing a STEM career. However, there is no evidence as to whether this role model intervention had a subsequent impact on the girls' actual enrolment in STEM fields.

Canaan and Mougaine (2021) investigate the impact of academic advisers' gender on university students' decisions on major. They take advantage of a random assignment of academic advisers of first-year students at the American University of Beirut. Using administrative data, the authors empirically estimate the effect of exposure to a female adviser, as opposed to a male adviser. The results confirm the role-model aspiration effect for female students in STEM fields. Specifically, female students assigned to female advisers from science departments are more likely to enrol in STEM majors afterwards and graduate with degrees in STEM, relative to male students. The authors estimate that accordingly the gender gap in STEM enrolment is reduced by 8.6 percentage points, and persistently the gender gap in STEM graduation is reduced by 7.2 percentage points. They show that the effects are driven by students with high ability in maths, even though similar positive effects are found for the grade point average of female students of all ability levels. Notably, no such effects are detected when the advisers are from non-science departments.

Porter and Serra (2020) conducted a field experiment testing the role model effect on the choice of university major at a small private university in Texas. Their intervention randomly exposed university students who were taking the introductory class in economics to 15-minute visits by female role models who had majored in economics at that same university. The role models in the intervention are career women, as opposed to most other previous interventions (e.g. in STEM), which have relied on instructors at university as role models. The authors find that the intervention almost doubled the likelihood of female students in the introductory economics classes deciding to major in economics, from 9% at baseline to 17%. No effects on male students were found using triple-difference estimations. Moreover, the authors find that the increase in female enrolment in economics is at the expense of female enrolment in humanities rather than STEM fields, and the female students pitched into economics by female role models are as academically competent as the other female students in economics.

5.3 De-tracking reforms

There is mixed evidence concerning the effects of de-tracking reforms. For example, Pekkarinen (2008) relies on a quasi-experiment related to a tracking reform implemented in the Finnish education system in the 1970s in order to identify the effect of educational tracking on educational attainment. The reform delayed the age at which Finnish students choose between two tracks – vocational or academic schools – from the age of 10-11 to the age of 15-16. The author takes advantage of the spatial variations at the time of implementing this de-tracking reform across Finland, and estimates the effect through a linear difference-in-difference approach by comparing the outcomes of individuals who belong to the same birth cohort but have different treatment status. The results indicate this reform had insignificant and negligible overall effects on the probability of choosing academic over vocational education, on continuing to academic tertiary education and on earnings. The effects for all three outcomes were nonetheless positive though small among females, while insignificant and negative among males (except for boys with uneducated fathers) and thus translate into narrowing the effects of gender gaps in educational and labour market outcomes. Specifically, the author estimates a 3 percentage point increase in the gender difference in getting into academic secondary school and a 4 percentage point decrease in the gender difference in getting into academic tertiary education, both in favour of girls. These translated into a 4.1 percentage point decrease in the gender wage gap as a result.

On the other hand, Canaan (2020) studies the long-run effects of a de-tracking reform in the French education system implemented in 1977-78. This reform postponed the age of tracking to 13 and added ability grouping to the education system at the age of 11, where students are divided into different groups by academic ability while still following the same general education curriculum. To take advantage of this natural experiment, the author adopts a regression discontinuity approach to estimate the effect of de-tracking on educational and labour market outcomes in the long run. The effects are found to be heterogenous across several dimensions. Higher effects are identified among individuals from families with disadvantaged socioeconomic status and among males compared with females, with the effects driven by people with both French-born mothers and French-born fathers. On the gender dimension, the author estimates fully flexible models separately on the two gendered sub-samples, and reports that this de-tracking reform made holding a VET degree or dropping out of high school 30% less likely for men and increased the male wage by 8.2%. By contrast, it had no effect on employment for men or on any of these outcomes for women.

6. Conclusion

The gender gap in educational attainment has not just closed but has reversed in tertiary education in the majority of the EU's 27 member states. However, significant gender gaps remain across fields of study and in STEM. Gender gaps in educational choices emerge early in secondary schooling, and then widen along the educational trajectory. Existing research provides evidence of a complex set of determinants, though the magnitude of the effects varies across countries and over time. Among other explanatory factors, the educational context, the structure of the labour market and the environment of the workplace, as well as broader gender equality in cultural values and social norms in society, appear to play important roles.

Given the nature and magnitude of the gender gaps, and the fact that they alter by educational stage, different policies and interventions are needed along the educational trajectory. Current evidence on the effectiveness of policies and interventions converges toward showing the importance of teachers and role models. Other interventions do not allow the drawing of more general conclusions. While a number of other initiatives have recently been introduced across member states there is still limited comparable and rigorous evidence of their impact in the European context. More research is needed, together with the systematic collection of data and education statistics that provide the gender decomposition (e.g. in the field of artificial intelligence and other related sub-fields).

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Appendix. Education datasets for the EU's 27 member states

The EU-27, from 31 January 2020, refers to Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden.

Table A1. Educational attainment: primary, secondary, tertiary (higher education, VET)

#	Dataset	Description	Educational outcomes	Countries covered	Period
1.	Eurostat, enrolment rates data	• Aggregate data for European countries on participation in education and training • Aggregate information provided by ○ gender ○ age ○ country ○ NUTS2 region ○ type of institution ○ age group ▪ early childhood education and primary education ▪ lower secondary, upper secondary and post-secondary non-tertiary education ▪ tertiary education Data available at: https://ec.europa.eu/eurostat/web/education-and-training/data/database	Enrolment rate by gender, type of institution and intensity of participation	EU-27	• All datasets available for 2012-19 • Some data available back to 2005
2.	European Data Portal	• Data portal built to be a single point of access to open data produced by EU institutions and bodies • The portal provides access to country-level data (individual or aggregate) available by gender on ○ participation rates ○ choice of the field of education The education data in the portal can be accessed at: https://bit.ly/3jihDsK	Enrolment rates by gender	EU-28	Last update: 2021

		Portal website: https://www.europeandataportal.eu/fr			
3.	OECD data on enrolment rates by education level	• Aggregate data • Available by gender and by age groups • Data available by level of education: primary, secondary, tertiary Data available at: https://data.oecd.org/eduatt/population-with-tertiary-education.htm	Share of the population with a given level of education (i.e. tertiary education)	OECD countries	Last update: 2019

4.	World Bank data on enrolment rates	• Aggregate data at the country level
		• Data available by gender
		• School enrolment data by education level:
		  ○ pre-primary
		  ○ primary
		  ○ secondary
		  ○ tertiary education
		
		Data available at:
		https://data.worldbank.org/indicator/SE.PRM.ENRR.FE
			Enrolment rates	World (developed countries report figures back to the 1970s)	1970-2020

5.	Lee and Lee (2016) Long-Run Education Dataset	• Aggregate country-level ratios • Available by gender • Data available by level of education and by age group • Data go back to 1820, and it is available for every five-year period (1820-25, 1825-30, etc.) Data available at: https://barrolee.github.io/BarroLeeDataSet/DataLeeLee.html	• Enrolment ratios by levels • Education attainment for the population by age groups • Human capital stock the for population aged 15-64	111 countries Authors classify the following countries as 'advanced economies': Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland,	1820-2010

				Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the US and the UK Further details on regional classifications are available in the source paper.	
6.	European Agency Statistics on Inclusive Education	• Country-level data • Aggregate data • Available by gender • Data reports the number of students with special needs enrolled in the education system Data available at: https://www.european-agency.org/data	Number of pupils with special needs in the member countries	EU-28 and partner countries	1999-2019

Source: Author's compilation.

Table A1.1 Field of education (VET, tertiary)

#	Dataset	Description	Educational outcomes	Countries covered	Period

1.	Eurostat, enrolment rate by field of education	• Aggregate data for European countries on participation rates by gender and field of education
		• Aggregate information provided by
		  ○ gender
		  ○ age
		  ○ country
		  ○ NUTS2 region
		  ○ type of institution
		  ○ age group:
		    ▪ post-secondary non-tertiary education by programme orientation
		    ▪ vocational upper secondary and post-secondary non-tertiary education
		    ▪ tertiary education and field of education
		  ○ all education levels by level, gender and field of education
		
		Data available at:
		https://ec.europa.eu/eurostat/web/education-and-training/data/database
			Enrolment rate by gender and by field of education	EU-27	2012-19

2.	ETER (European Tertiary Education Register)	• Individual-level data on students enrolled in higher education institutions in European countries: 2,465 higher education institutions hosting more than 17 million students • Data available by gender • Information available on the field of study, institution and faculty members for each institution Presentation site: https://ec.europa.eu/education/european-tertiary-education-register_en Data portal: https://www.eter-project.com/#/search	Enrolment rate by field of study and by level of higher education: • Bachelor • Master • Ph.D.	EU-27 and partner countries	2011-14
3.	OECD statistics,	• Data at the country level • Data available by gender	Number of graduates by field	OECD countries	2005-18

	graduates by field of study (secondary and tertiary)	• Aggregate number of students by field of education • Data available by ○ field of education (STEM/other fields) ○ education level (secondary education, VET, bachelor's, master's, Ph.D.) Data available at: https://stats.oecd.org/index.aspx?lang=en	of study and by type of degree		
4.	UNESCO, share of female graduates by field of study	• Aggregate data by country • Data available by gender • Data available by field of study (STEM/others) in tertiary education Data available at: http://data.uis.unesco.org/index.aspx?queryid=165	Percentage of female graduates by field of study in tertiary education	Data available for all developed countries	2013-19

Source: Author's compilation.

Table A1.2 School systems, streaming and higher education

#	Dataset	Description	Educational outcomes	Countries covered	Period
1.	Eurydice	• Educational network reporting descriptions of national education systems • For each member country, the national education system is described in detail from early childhood to university (including the Ph.D. system) • Data can be collected manually for each country (no consolidated data on indicators is available) Data available at: https://eacea.ec.europa.eu/national-policies/eurydice/national-description_en	Descriptions of the national education systems in member countries	EU-27 and partner countries	Last updated in 2019; changes in policies are documented
2.	Fournier, Lefresne, and Rakocevic (2019), data on national systems of education	• Report on the differences between the national educational systems in the EU (chapter 2) • Initial data from Eurydice Report and data available at: https://www.education.gouv.fr/education-europe-key-figures-ed-2018-11942	• Structure of the education system • First year of streaming	EU-28	2018
3.	Hanushek and Wößmann (2006), first year of streaming data	Country-level data, with the age at which the first streaming takes place Data available at: http://hanushek.stanford.edu/download	Year at which the first streaming takes place	Developed countries (OECD and partner countries)	Data published in 2006
4.	Orr et al. (2017), data on systems of higher education	Cross-country analysis on the system of higher education Report available at: https://op.europa.eu/en/publication-detail/-/publication/9cfdd9c1-98f9-11e7-b92d-01aa75ed71a1	Higher education admission system	EU-28	2017

Source: Author's compilation.

Table A2. Learning outcomes

#	Dataset	Description	Educational outcomes	Countries covered	Period
1.	PISA (Programme for International Student Assessment)	• PISA evaluates students' performance in reading, mathematics, and sciences every three years • The target population: national representative samples of 15-year-old students • Individual-level data available by gender • Data include ○ individual-level information and students' background ○ information on parents' background and on school resources and teachers Data available at: https://www.oecd.org/pisa/data/	Performance (measured by test scores) in • Reading • Mathematics • Science	OECD countries and selected partner countries (the complete list of countries participating in each wave is presented in section 4, subsection A).	7 waves: • 2000 • 2003 • 2006 • 2009 • 2012 • 2015 • 2018
2.	TIMSS (Trends in International Mathematics and Science Study)	• TIMSS evaluates students' performance in mathematics and science every four years • The target population: a nationally representative sample of students in the fourth and eighth grades • Quasi-longitudinal design, with the fourth grade student cohort assessed four years later at the eighth grade • Individual-level data available by gender • Data include ○ individual-level information and student background ○ information on parents' background, on schools and on teachers Data available at: https://timssandpirls.bc.edu/timss-landing.html	Performance (measured by test scores) in • Mathematics • Science	Developed countries; the complete list of countries by wave is presented in section 4 – subsection B	7 waves: • 1995 • 1999 • 2003 • 2007 • 2011 • 2015 • 2019
3.	TIMSS Advanced	• TIMSS Advanced measures achievement in advanced mathematics and physics for students in their final year of secondary school • The target population: students undertaking advanced mathematics and physics courses in their final year of secondary school or at the start of their STEM	Performance (measured by test scores) in • Advanced mathematics	Developed countries; the complete list of countries by wave is presented in	3 waves: • 1995 • 2008 • 2015

		coursework in universities (schools are sampled to be national representatives)
		• Individual-level data available by gender
		• Data include
		  ○ individual-level information and student background
		  ○ information on parents' background and on schools and teachers
		
		Data available at: https://timssandpirls.bc.edu/timss-landing.html
			• Physics	section 4 – subsection C	

4.	PIRLS (Progress in International Reading Literacy)	• PIRLS evaluates student's performance in reading achievements every five years
		• The target population: a nationally representative sample of students in the fourth and eighth grades
		• Individual-level data available by gender
		• ePIRLS monitors how well fourth-grade students read online information
		• Data include
		  ○ individual-level information and student background
		  ○ information on parents' background and on schools and teachers
		
		Data available at: https://timssandpirls.bc.edu/pirls-landing.html
			Performance (measured by test scores) in reading		4 waves:
					• 2001
					• 2006
					• 2011
					• 2016

5.	ICILS (International Computer and Information Literacy Study)	• ICILS evaluates international differences in students' computer and information literacy; the study measures students' performance on how well they are prepared for study, work and life in a digital world • The target population comprises students in their eighth year of schooling. In most education systems, the eighth year of schooling is grade 8, provided that the average age of students in this grade is 13.5 years or above. In education systems where the average age in grade 8 is below 13.5, grade 9 is defined as the ICILS target population	Students' achievement in digital literacy: students' ability to use computers to investigate, create and communicate in order to participate effectively at	Participating countries in one or both of the two waves: Australia, Chile, Croatia, Czech Republic, Denmark, Finland, France,	2 waves: • 2013 • 2018 Upcoming wave: 2023

		• Individual-level data available by gender • The study contains student, teacher and school data Presentation website: https://www.iea.nl/studies/iea/icils Data available at: https://www.iea.nl/data-tools/repository/icils	home, at school, in the workplace and in the community	Germany, Hong Kong SAR, Italy, Kazakhstan, Republic of Korea, Lithuania, Luxembourg, Netherlands, Norway (grade 9), Poland, Portugal, Russian Federation, Slovak Republic, Slovenia, Switzerland, Thailand, Turkey, the US, Uruguay	

Source: Author's compilation.

Table A3. Adult skill proficiency and employment

#	Dataset	Description	Educational outcomes	Countries covered	Period
1.	PIAAC (Programme for the International Assessment of Adult Competencies)	• Individual-level data • Target population: adults aged 16 to 65 in their homes – 5,000 individuals in each participating country • Cross-country, cross-cultural and cross-national validity • The study assesses literacy and numeracy skills and the ability to solve problems in technology-rich environments • Information on how skills are used at work and in other contexts, such as the home and the community Data available at: https://www.oecd.org/skills/piaac/data/	Literacy and numeracy skills	OECD and partner countries	1st cycle: 2011-18 2nd cycle: 2018-23
2.	IALS (International Adult Literacy Survey)	• Individual-level data • Available by gender • Adult population: aged 16 to 64 • Results were rescaled such that international comparisons are valid Data access: the rescaled IALS public-use files of the countries that participated in the survey can be requested from Statistics Canada by emailing fe-education@statcan.gc.ca.	Adult literacy in • Prose • Document • Quantitative dimensions	22 developed countries: Canada, the Netherlands, Switzerland, Germany, Poland, the US, Ireland, Sweden, Australia, Great Britain, Northern Ireland, Belgium (Flemish), New Zealand, Chile, Finland, Norway, Czech Republic, Hungary, Slovenia, Denmark, Italy,	1 wave: 1994-98

				Switzerland (Italian-speaking region)	
3.	ALL Survey (Adult Literacy and Lifeskills)	• Individual-level data • Available by gender • Adult population: aged 16 to 64 • Results were rescaled such that international comparisons are valid Data access: the rescaled ALL public-use files of the countries that participated in the survey can be requested from Statistics Canada by emailing fe-education@statcan.gc.ca.	Literacy in • Prose and documents • Numeracy • Problem solving	Italy, Norway, Switzerland, Bermuda, Canada, Nuevo Leon (Northern Mexico), the US, Hungary, the Netherlands, Australia, New Zealand	2 waves: 2003-06 and 2006-08
4.	UNESCO, literacy rate	Adult literacy data: • Aggregate data at the country level • Data available by gender • Share of literate individuals by age group Data available at: http://data.uis.unesco.org/index.aspx?queryid=166	Literacy rate by age and gender	World	2013-19
5.	World Bank data, literacy rate	Adult literacy data: • Aggregate data at the country level • Data available by gender • Share of literate individuals by age group Data available at: https://data.worldbank.org/indicator/SE.ADT.LITR.ZS	Literacy rate by age and gender	World	1970-2019

Source: Author's compilation.

Table A3.1 STEM data

#	Dataset	Description	Educational outcomes	Countries covered	Period
1.	Eurostat, enrolment rate by field of education	Students enrolled in tertiary education by education level, programme orientation, gender and field of education • Aggregate data for European countries on enrolment rate in tertiary education by field of education • There are 180 defined fields, including electronics and automation; engineering and engineering trades; engineering, manufacturing and construction; mathematics; mathematics and statistics; and physics • The 180 fields can be grouped into the 11 categories defined by UNESCO: ○ Generic programmes and qualifications ○ Education ○ Arts and humanities ○ Social sciences, journalism and information ○ Business, administration and law ○ Natural sciences, mathematics and statistics ○ Information and communication technologies ○ Engineering, manufacturing and construction ○ Agriculture, forestry, fisheries and veterinary ○ Health and welfare ○ Services • Data available by gender Data available at: https://bit.ly/2ZKFNV7	Enrolment rate by gender and by field of education	EU-27	2012-19
2.	ETER (European Tertiary Education Register)	• Individual-level data on students enrolled in higher education institutions in European countries • Information on students and on schools • Data available by gender • Field of study information is aggregated by the following categories: ○ Generic programmes and qualifications ○ Education ○ Arts and humanities	Enrolment rate by field of study and by level of higher education: • Bachelor • Master • Ph.D.	EU-27 and partner countries	2011-14

		○ Social sciences, journalism and information ○ Business, administration and law ○ Natural sciences, mathematics and statistics ○ Information and communication technologies ○ Engineering, manufacturing and construction ○ Agriculture, forestry, fisheries and veterinary ○ Health and welfare ○ Services Presentation site: https://ec.europa.eu/education/european-tertiary-education-register_en Data portal: https://www.eter-project.com/#/search			
3.	OECD statistics, graduates by field of study (secondary and tertiary)	• Data at the country level • Data available by gender • Aggregate number of students by field of education • There are 65 defined fields of education in the data grouped in the following 11 categories: ○ Generic programmes and qualifications ○ Education ○ Arts and humanities ○ Social sciences, journalism and information ○ Business, administration and law ○ Natural sciences, mathematics and statistics ○ Information and communication technologies ○ Engineering, manufacturing and construction ○ Agriculture, forestry, fisheries and veterinary ○ Health and welfare ○ Services Data available at: https://stats.oecd.org/index.aspx?lang=en	Number of graduates by field of study and by type of degree	OECD countries	2005-18
4.	UNESCO, share of female graduates by field of study	• Aggregate data by country • Data available by gender • Data available by field of education: ○ Generic programmes and qualifications ○ Education	Percentage of female graduates by field of study in tertiary education	Data available for all developed countries	2013-19

		○ Arts and humanities ○ Social sciences, journalism and information ○ Business, administration and law ○ Natural sciences, mathematics and statistics ○ Information and communication technologies ○ Engineering, manufacturing and construction ○ Agriculture, forestry, fisheries and veterinary ○ Health and welfare ○ Services Data available at: http://data.uis.unesco.org/index.aspx?queryid=165			

Note: All datasets define the field of education and training as described in the 1997 International Standard Classification of Education (ISCED-97).

Source: Author's compilation.

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