3

GENDER EQUALITY IN ICT INDUSTRY LEADERSHIP

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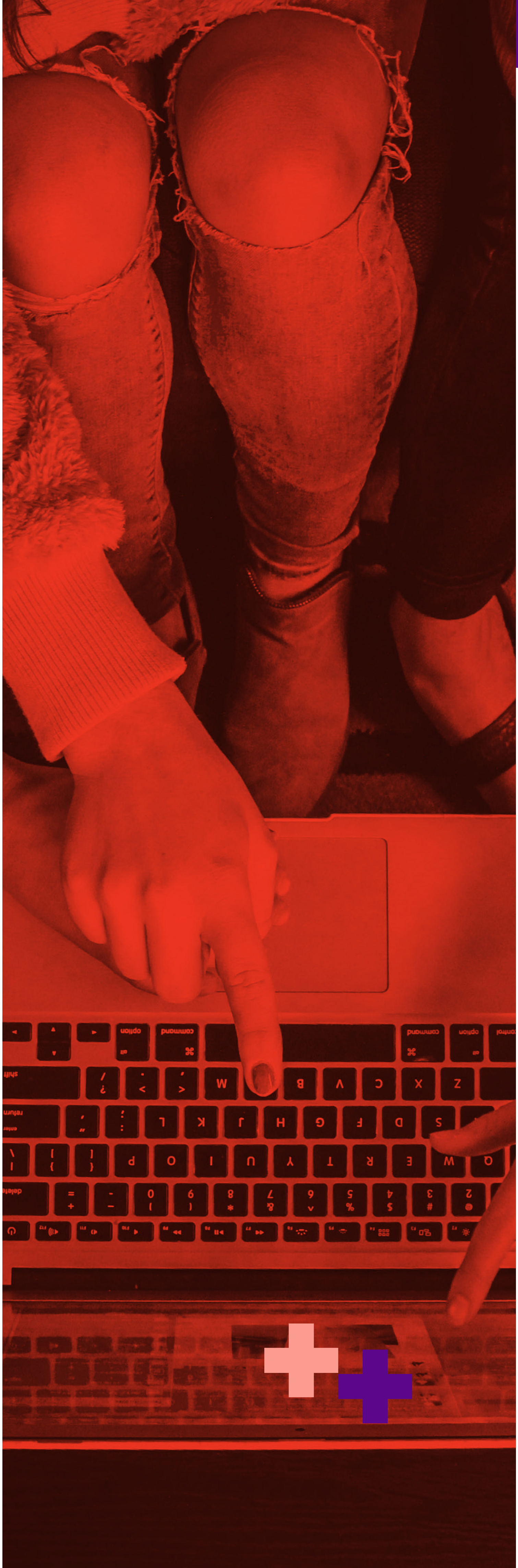


KEY FINDINGS

- Although gains have been made, women's representation remains low across different dimensions of ICT employment, entrepreneurship, and policymaking. On average, women constitute less than 35% of ICT and related professions. However, there is wide variation by country and by ICT sub-sector, ranging from as low as 2% to as high as 60%.
- Women in ICT tend to be in junior and support rather than managerial roles. Where women have made inroads into management, they are often in staff positions rather than the line positions that constitute the main pathway to executive roles.
- Evidence from North America and Europe indicates that women leave science and engineering jobs at higher rates than men. Their reasons for doing so are contested; some researchers cite family demands, while others point to workplace discrimination.
- Women are less likely than men to start enterprises in the ICT sector.
- Women have a very low rate of leadership in ICT policymaking. Worldwide, only 28 countries have a woman ICT minister, and only 25 have a woman heading the telecom regulator.

3.1 / INTRODUCTION

To what extent are women gaining employment in ICT and related industries, and what is their representation at senior management levels? Are women engaged in digital entrepreneurship, and how does their access to business capital compare to men's? This chapter draws on existing research and data to explore the question: What is the current status of women's participation in ICT industry leadership around the world? We review the literature on dimensions of gender equality in leadership within the ICT industry, presenting relevant data where available, and we discuss knowledge gaps and implications. Our starting premise is that women are capable of leadership in ICT fields, and that there is often a sizable pool of talented women for existing technology jobs.[5]

3.1.1 / WHY IS WOMEN'S EQUAL LEADERSHIP IN THE ICT INDUSTRY IMPORTANT?

The case for gender equality in technology leadership is usually presented as either an ethical argument or a business argument. From the ethical perspective, advocates note that in the digital age, technology jobs usually command more power, greater prestige, and higher pay. Those jobs are also more influential in driving economic development and producing the systems and tools that shape people's lives (Frehill, Abreu, & Zippel, 2015; Sassler, Michelmore, & Smith, 2017). Low proportions of women in leadership means that women's ability to have decision-making impact within the industry is limited. This argument aligns with the UN's Sustainable Development Goals, several of which advocate gender equality in the labour force (Box 3.1). Part Two of this report presents discussions on the importance of gender-diverse participation in designing information security technology (Chapter 13), technology innovation and transfer (Chapter 17), and artificial intelligence systems (Chapter 18), as well as reflections on the tendency to devalue women's work at all levels (Chapters 14 and 16).

Box 3.1
Women's ICT leadership and the SDGs

While none of the SDGs refer specifically to women in the technology industry, several targets are relevant to gender equality in tech. Progress on the related indicators would contribute to an enabling environment and signal progress in bringing more women into leadership in the technology industry.

Target 5.1: End all forms of discrimination against all women and girls everywhere.

Target 5.4: Recognise and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate.

Target 5.5: Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.

Target 5.C: Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels.

Target 8.5: By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.

5 *See World Economic Forum(2017) analysis of LinkedIn members skill profiles.*

More recently, arguments have shifted to targeting organisations' self-interest by outlining business arguments for gender equality. Proponents, backed by research, argue that diversity leads to organisational benefits, such as improved financial health and returns on investment, higher staff productivity, a healthier workforce, and more creative problem-solving (Chanavat & Ramsden, 2013; Dawson, Kersley, & Natella, 2014; Gompers & Wang, 2017a; V. Hunt, Layton, & Prince, 2015; V. Hunt, Yee, Prince, & Dixon-Fyle, 2018; ILO, 2017a; Thomas, Dougherty, Strand, Nayar, & Janani, 2016; Vasilescu et al., 2015). For example, Thomas et al. (2016) found a correlation between diversity in tech company workforces and higher revenues, profits, and market value (in the U.S. and globally). They estimated that closing the global gender leadership gap could generate up to a 0.6% increase in global GDP. Companies in the U.S. and UK with the most gender diverse teams (especially at executive level) are 21% more likely to outperform other companies on profitability, according to (Hunt et al., 2018). More inclusiveness could also help to address industry skills shortages (e.g., Hewlett & Sherbin, 2014).

3.1.2 / MEASURING GENDER EQUALITY IN THE ICT INDUSTRY

Because technology now permeates every industry sector and an increasing number of job roles, the lines have blurred noticeably, making it more difficult to precisely quantify the tech workforce. (CompTIA, 2018, p. 11.)

There is no single high-tech industry; rather, new technology has transformed industries . . . and the functions of numerous occupations. . . . Occupations unknown a decade earlier have become common. . . . Classification schemes that rely on a single measure of technological expertise, as many do, may incorrectly rank industries and/or classify sectors. (U.S. Equal Employment Opportunity Commission, 2016, p. 4.)

Gaining an understanding of the true state of gender equality in the ICT industry presents several research and data collection challenges. First, there is lack of sufficiently fine-grained gender-disaggregated, consistently collected and comparable occupational data at the sector level for most countries (Data 2x, 2017; WIT Leadership Round Table Metrics Working Group, 2016). This limits researchers' ability to compile data at the global level and to do cross-country analyses. Most organisations do not collect and/or share diversity data, either because they are not required to do so by law or because they are reluctant to do so (Donnelly, 2017; Evans & Rangarajan, 2017).

Secondly, significant definitional issues affect this type of research. The continually evolving nature of technology developments gives rise to questions such as, what falls within the ICT industry, what constitutes an ICT or ICT-related occupation, and what does it mean to be a leader in this context. With the tentacles of digital technology reaching into diverse sectors, there are now at least three contexts in which a person could have an ICT-related occupation: 1) within the formal ICT industry; 2) within the informal ICT industry (e.g.; unregistered microenterprises, black market); and 3) within non-ICT sectors that make intensive use of technology (e.g., health sector). Different categorisations schemes — many of which collapse ICT sectors into general technology groupings — often make it necessary to use a technology as a proxy for ICT or to measure a narrow slice to represent the larger ICT category (Appendix D)[6]. This report is primarily concerned with gender equality in the ICT sector, particularly the formal ICT industry, where more adequate conceptualisation, research, and data collection exist. Future efforts should acknowledge and account for the informal[7] and non-ICT contexts as well.

The definition of a leadership position also impacts what situations are captured. Leadership can be found within the ranks of people working in technical roles, but also within the broad category of management, which includes people in non-technical roles. Indeed, technology company executives often come from non-technical positions (WIT Leadership Round Table Metrics Working Group, 2016).

The remainder of this chapter presents gender and ICT leadership in three areas – employment, entrepreneurship, and policymaking (Box 3.2). We also review research on the factors that constrain women's participation in the ICT industry and discuss potential remedies. Because much of the available data represent the broader science and technology industry, the analyses will often rely on technology industry data to signal the general status of women in the ICT industry.

For a comprehensive assessment of gender equality in the ICT industry, the WIT Leadership Round Table Metrics Working Group (2016, p. 3) recommends looking at both stationary metrics (e.g., female hires relative to all hires, or percentage of women at different organisational levels) and flow metrics (e.g., women promoted relative to all promotions, or attrition rates among women and men). This level of granularity — especially of flow data — is mostly unavailable through global public data sources, although individual organisations may have such data in their administrative records. We therefore focus on recruitment, retention, advancement, and work environment trends for industry in general, referring to specific data on the ICT industry where available.

6 *For example, Blau, Brummund, and Liu (2013) demonstrate how changes to occupational coding systems can affect research results. Also see UNCTAD (2015).*

7 *This particularly applies to low- and middle-income countries where a high proportion of the population are employed in the informal sector (ILO, 2018).*

Box 3.2
Aspects of gender & ICT leadership

Employment
working as an employee:
- Recruitment
- Retention
- Advancement

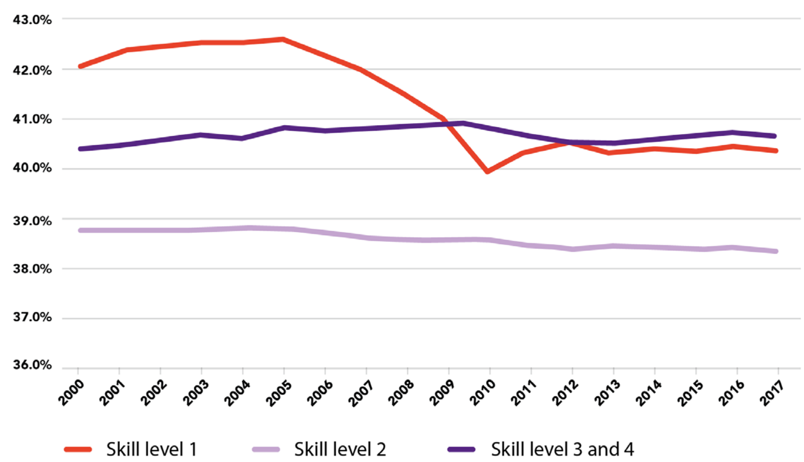
Entrepreneurship
establishing one's own enterprise in the industry (with or without employees):
- Participation
- Access to business training
- Access to business capital

Policymaking
working in an organisation that determines policy on technology and related issues:
- Recruitment

3.2 / EMPLOYMENT – RECRUITMENT

This section covers gender-relevant recruitment trends for selected occupational skill levels, technology-related industries, and technology-related occupations, supplemented with regional or country-specific data when possible.

Figure 3.1
Percentage of women employees at three occupation skill levels, global



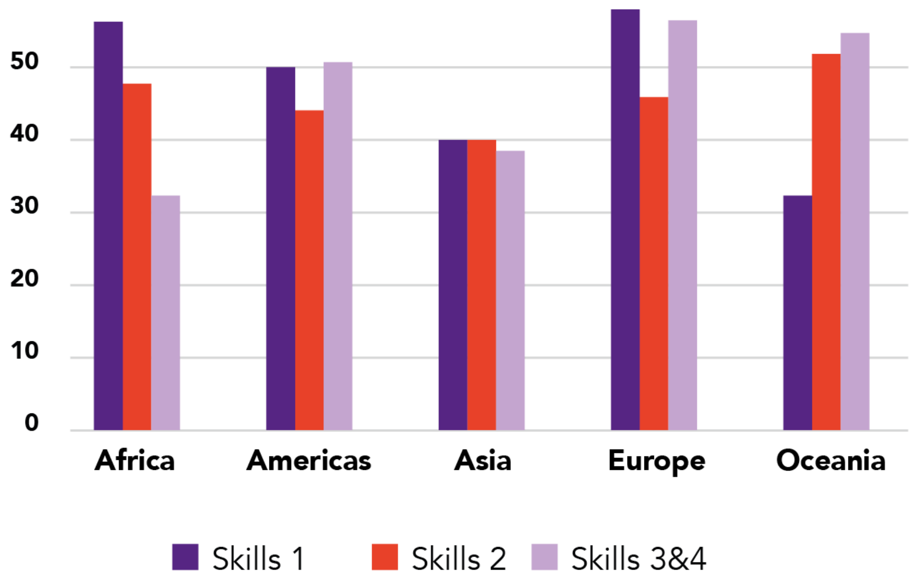
Source: ILOSTAT, ILO modelled estimates.
Notes: ILO defines skill levels as follows: Level 1 (low) = Elementary occupations; Level 2 (medium) = Clerical support workers, Service and sales workers, Skilled agricultural, forestry and fishery workers, Craft and related trades workers, Plant and machine operators, and assemblers; Levels 3 and 4 (high) = Managers, professionals, and technicians. See ILO indicator description: http://www.ilo.org/ilostat-files/Documents/description_OCU_EN.pdf
Robust data (Africa=53, Americas=33, Asia=51, Europe=40, Oceania=11) across all years and skill levels. Regional differences relatively stable from 2000-2017. Proportion of women is calculated by number of women workers/total number of workers per skill level.

3.2.1 / OCCUPATION SKILL LEVELS

Since leadership in the technology industry tends to require relatively high technical and/or managerial skills, it is instructive to first examine global data on women's employment at different skill levels. This data covers all industries and does not distinguish between ICT and non-ICT occupations. Globally, women's participation in jobs requiring high (level 3 and 4) skill levels has consistently been slightly above 40% since 2000 (Figure 3.1).

Although the data span both technology and non-technology industries, they do indicate fairly high levels of women employed in occupations that are associated with high skills, especially in Europe (51%), Oceania (50%), and the Americas (46%) (Figure 3.2). In Africa, however, progressively higher skill occupations are associated with lower proportions of women; the opposite applies in Oceania; and the numbers converge at around 35% for Asia. The picture is more mixed in Europe and the Americas, where the highest proportions of women are found at the extremes, in Level 1 and Level 3-4 jobs. Notably, there has been very little change in these trends over the last two decades, apart from a large drop in the proportion of women in low-skill (Level 1) occupations. The reasons for this drop are unclear, as it is not associated with a corresponding increase in employment at other skill levels. One possibility is that it could be an artifact of changes in data collection methods or the number of countries reporting.

Figure 3.2
Percentage of women by occupation skill level (2017)



Source: ILOSTAT, ILO modelled estimates.

3.2.2 / ICT INDUSTRIES AND RELATED FIELDS

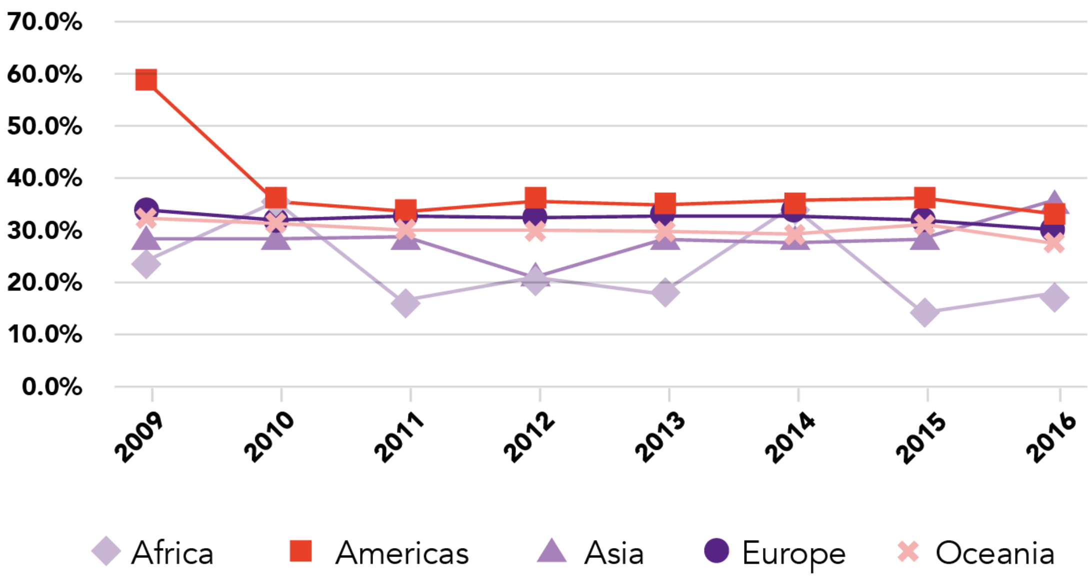
Most studies of gender diversity in the technology industry focus either on specific countries (usually the U.S.), geographic locations (e.g., Europe, Silicon Valley) or large global companies (e.g., Fortune 500, FTSE100, S&P100). While individual organisations show some variation[8], on average, levels of participation by women are low and the pace of change is slow. Thus, although (as the previous section notes) 40% of high-skill occupations are filled by women, it appears these jobs are mostly not in the ICT industry. The proportion of women in the U.S. technology industry, for example, remained at 22% between 2005 and 2015, according to the US Government Accountability Office (2017).

Even women technology workers were more likely to be employed outside the technology industry than within it. Similar findings were reported for Silicon Valley: women's employment was 30% in leading tech firms compared to 49% in non-tech firms (U.S. Equal Employment Opportunity Commission, 2016). In Europe, women comprised 21% of the workers in the digital work force (Quirós et al., 2018).

A global study of 54 telecommunications companies found that most (75%) had female employment between 10% and 40% of their workforce, and only one had more than 50% (Molina, Lin, & Wood, 2015). This finding is consistent with ILO data, which show levels between 18% (Africa) and 35% (Asia) in 2016 (Figure 3.3). The 2016 median for each region was between 28% and 34% (Table 3.1). However, Table 3.1 also shows that the averages mask wide variations between countries.

8 *For example, in 2016, both Pandora and Groupon had about 48% female employees (Information is Beautiful, 2018).*

Figure 3.3
Percentage of women telecommunications industry employees



Source: ILOSTAT, ISIC level 2.
Note: Includes self-employment. Thin data for most countries.

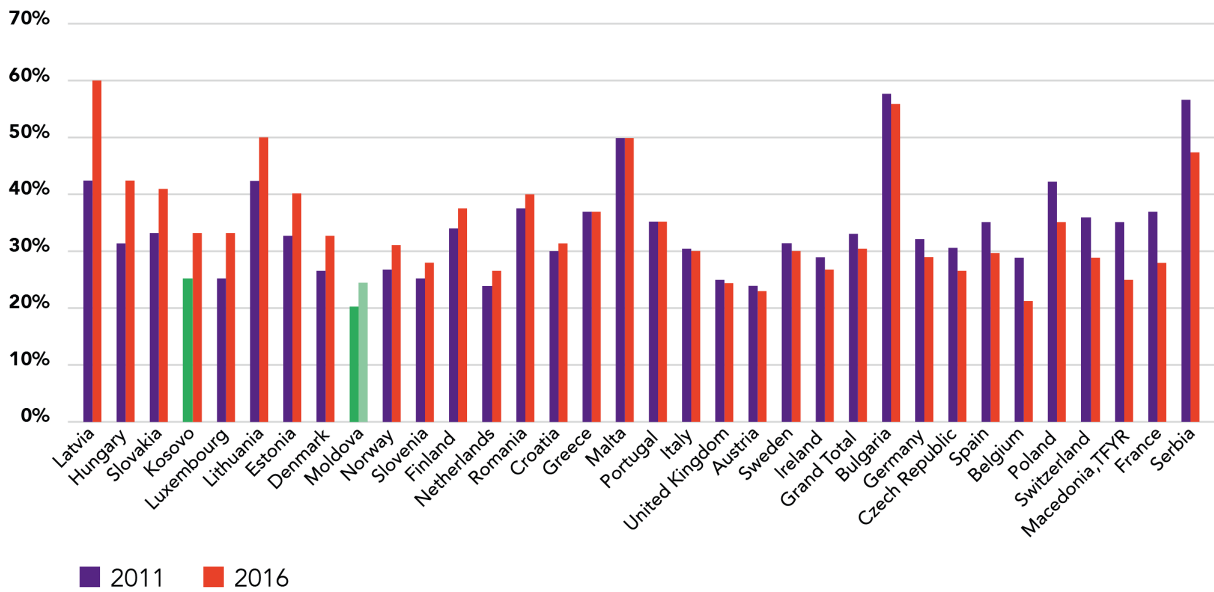
Table 3.1
Percentage of women employees in telecommunications industry, by region

REGION	2010	2016	MEDIAN 2016	LOWEST PERCENTAGE	HIGHEST PERCENTAGE	NUMBER OF REPORTING COUNTRIES
Africa	35,5	17,9	33,3	11 (Mali)	55 (Uganda)	13
Americas	35,8	33,2	33,3	21 (Guatemala)	51 (Ecuador)	11
Asia	28,1	35,3	34,4	5 (Pakistan)	50 (Mongolia)	18
Europe	32,4	30,5	32,3	17 (Bosnia/Herzegovina)	60 (Latvia)	36
Oceania	31,8	27,6	28,2	28 (Australia)	29 (New Zealand)	2

Source: ILOSTAT, ISIC level 2.
*Percent for last known year

Because of the limited number of reporting countries, however, the trends displayed in Figure 3.3 are only meaningful for Europe, where multiple countries have reported consistently over the years. By 2016, only three of Europe's 32 reporting countries had reached or exceeded parity (Figure 3.4). A closer look at changes between 2011 and 2016 shows a lot of variation at the country level: women's share increases in some countries (15 countries), remains essentially stagnant in a few (5 countries), and decreases in others (13 countries). Similar country variations can be seen in other world regions (Table 3.1). Regional analyses therefore need to be complemented with country-level breakdowns to get a true picture.

Figure 3.4
Percentage of women telecommunications industry employees, Europe



*Source:*LOSTAT.
Note: Kosovo uses 2014 data; Moldova uses 2014 and 2015 data.

3.2.3 / EMPLOYMENT IN ICT PROFESSIONS

Several studies confirm the existence of significant occupational segregation by gender (that is, gender concentration within specific fields), in both emerging and advanced economies, with women being most concentrated in education, health, and social work (e.g., Blau, Brummund, & Liu, 2013; ILO, 2017b). Furthermore, ILO reports that occupational segregation has "increased by one-third over the past two decades" (2017, p. 2). This tendency appears to be particularly pronounced in sectors related to ICTs. For example, women make up only 21.5% of the digital workforce in Europe (Quirós et al., 2018), 34% of the technology workforce in the U.S. (CompTIA, 2017), and 17% of IT specialists in the UK (BCS, 2017). After studying trends in computer and engineering education and employment in the U.S., Sassler et al. (2017, p. 19) conclude that "even though female employment throughout the life course has become increasingly normative in American society, and computer science jobs have proliferated and generally provide good wages, the occupation is not succeeding in drawing women. Instead, the evidence suggests that something about the field of computer science is repelling rather than attracting women." (See Chapter 5 for a discussion of reasons for women's low representation.) The Sassler study found that women with engineering and computer science degrees were 8% and 14% (respectively) less likely to work in STEM occupations than their men counterparts, suggesting that the engineering field is attracting more recent women graduates than the computer science field. The OECD Digital Economy Outlook placed the proportion of women workers who are ICT specialists at less than 2%, compared to over 5% for men (OECD, 2017).[9] In the cybersecurity field, a global study of 170 countries estimated that women constitute 11% of professionals (Frost & Sullivan, 2017). (For more detail on issues related to women's participation in the information security profession, see Part Two, Chapter 9 of this report.)

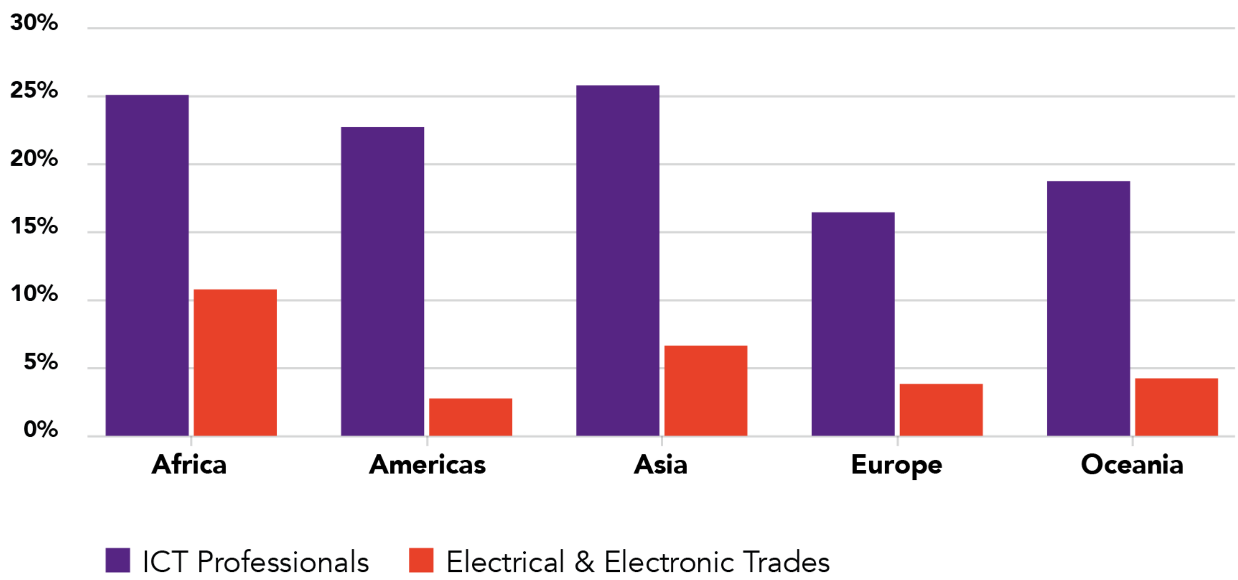
Other research, however, identifies contradictory trends, such as a decrease in occupational segregation among STEM graduates (Shauman, 2017). Furthermore, within the ICT industry, some sectors may be attracting higher proportions of women — for example, in the U.S., women's participation is only 27% in the Computer Systems Design sector, but almost 40% in Internet Publishing and Web Search Portals.

To explore this topic, we selected ICT-related professions for which some global data exists (using ILO occupational classification): ICT Professionals; Electrical and Electronic Trades Workers; and Science and Technology Researchers. Two other relevant professions, STEM Faculty and Software Developers, are also briefly discussed.

3.2.3.1 / ICT Professionals and Electrical and Electronic Trades

Overall, women represent less than 26% of ICT Professionals and Electrical and Electronic Trades employees (Figure 3.5). Europe, with the largest number of reporting countries, had roughly 15% to 17% women information and communication technology professionals between 2011 and 2016. The corresponding proportion of electrical and electronic trades workers in European countries was much lower — between 3% and 5% for the same period. Apart from a few spikes and drops that might be attributable to data gaps, regional trends have remained largely stable since 2011. At the country level, however, there are notable variations (Tables 3.2 and 3.3). For instance, women in Peru comprise 45% of ICT professionals and 60% of Electrical and Electronic Trades workers, compared to 14% and 2% in Mexico.

Figure 3.5
Percentage of female employees in ICT-related occupations, regional (2016)



Source: LOSTAT.

9 *ICT specialists are defined as people whose jobs include "tasks related to developing, maintaining and operating ICT systems and where ICTs are the main part of their job" (OECD, 2017, p. 183).*

Table 3.2
Percentage of female ICT professionals (%)

REGION	2010	2016	MEDIAN 2016	LOWEST PERCENTAGE	HIGHEST PERCENTAGE	NUMBER OF REPORTING COUNTRIES
Africa	29	25	33,3	19 (South Africa)	40 (Ethiopia)	5
Americas	22	22	25	14 (Mexico)	45 (Peru)	11
Asia	24	26	30,9	5 (Indonesia	34 (Thailand)	11
Europe	15	16	17,6	7 (Greece)	40 (Macedonia)	35
Oceania	16	19	19	19 (Australia)	-	1

Source: ILOSTAT (ISCO-08).
*Percent for last known year

Table 3.3
Percentage of female electrical and electronic trades workers

REGION	2010	2016	MEDIAN 2016	LOWEST PERCENTAGE	HIGHEST PERCENTAGE	NUMBER OF REPORTING COUNTRIES
Africa	8	11	8,6	2 (Algeria)	14 (South Africa)	4
Americas	8	2	4	2 (Mexico, Brazil, Ecuador)	60 (Peru)	9
Asia	29	7	3,7	>1 (Pakistan, Turkey)	24 (Philippines)	11
Europe	4	4	4	1 (several)	26 (Russia)	29
Oceania	5	4	35	2 (Australia)	67 (Fiji)	2

Source: ILOSTAT (ISCO-08).
*Percent for last known year.

3.2.3.2 / Software developers

At present, data on software developer employment is available mainly from individual countries or private surveys by the hosts of developer communities (such as Stack Overflow). OECD's intellectual property database also provides an avenue for investigating this topic, potentially covering a broader number of countries.

The software developer community appears particularly devoid of women, with potentially damaging consequences (Case Study 3.1). Analysis of a repository of intellectual property indicates that women comprise a very small proportion of R package developers (23%) and ICT patent holders (23%) in G20 countries (OECD STI, 2018). [10]

10 *R code is a free programming language and software environment for statistical computing (https://www.r-project.org/).*

Case Study 3.1

Women's participation in online software developer communities

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Participation in online developer communities is becoming one of the primary ways for software developers to learn new programming languages, improve their skills, develop collaborative projects, and find new job opportunities (David & Shapiro, 2008; Ford et al., 2016; Vasilescu et al., 2015). These communities boast millions of users — over 29 million on GitHub (2018) and over one million on Stack Overflow (2018). GitHub users contribute code to about 60 million public "repositories" on the site, which are used by recruiters in hiring decisions. Professional software developers also hone their skills by asking and answering questions on coding Q&A sites like Stack Overflow. Stack Overflow developers also gain a public reputation from answering questions, further boosting their attractiveness to recruiters. Developers are also increasingly participating in coding challenges to hone their skills and signal their coding prowess to potential employers, through sites such as HackerRank, among others (Richard et al., 2015). However, despite the potential for these online developer communities to support software developers in their professional development, our analyses of open survey data (made available by GitHub, Stack Overflow, and HackerRank in 2017), indicate that gender gaps in participation may exacerbate the existing gender gaps in ICT, discussed throughout this report.

Who participates in online developer communities?
While women are estimated to comprise nearly 20% of the software development workforce (Wang et al., 2018), their participation in online developer communities is only a fraction of that. In a survey of approximately 100,000 software developers using Stack Overflow, only 4% of respondents identified as female. On GitHub's survey of 5,500 users, only 2% identified as female. HackerRank, the coding competition site, came closer to replicating the estimated gender gap in software development overall, with 16% of the 25,000 respondents identifying as female.

Among the users of Stack Overflow and HackerRank, men were nearly 15% more likely to be senior developers, nearly twice as likely to be in manager positions, and nearly four times as likely to be in executive roles. Male respondents on HackerRank were also nearly 15% more likely than women to be in hiring positions. However, women were more likely than men to be new graduates and junior developers, suggesting a newly burgeoning female software developer workforce. In addition, women on Stack Overflow were nearly twice as likely as men to fill technical roles like "data scientist" and "development operations engineer", which were listed as the top two best-paying jobs in 2018 (GlassDoor, 2018). Thus, while women in online developer communities still face gaps in traditional leadership roles, they may be emerging as leaders in new technical developer roles.

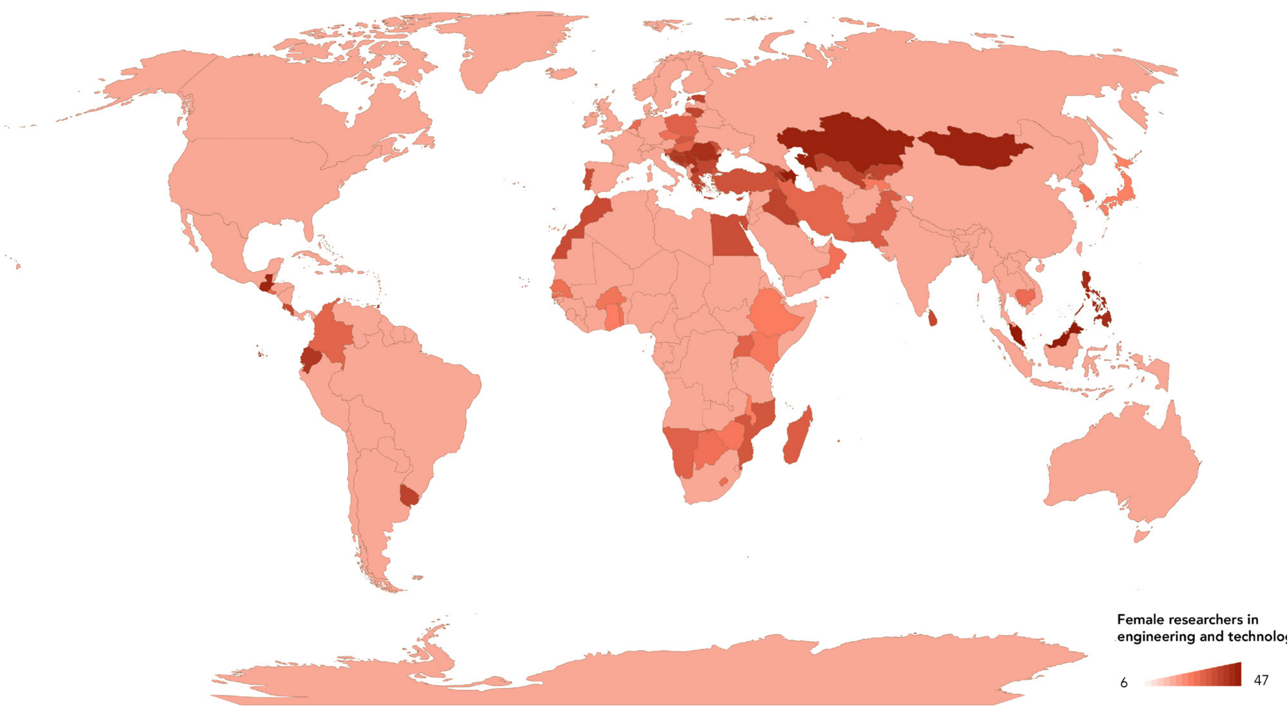
Do women and men participate differently?
On Stack Overflow, women were significantly less likely than men to have a registered account, and more likely to simply view Q&A on the site without responding or posting questions themselves. For GitHub, women were less likely than men to contribute code or "follow" other developers' repositories. These publicly visible acts of participation are precisely the types of "signaling incentives" that have been cited as a benefit of online developer communities for hiring decisions (e.g., Lakhani & Von Hippel, 2003; Vasilescu, 2014). In fact, when developers on GitHub were asked how interested they were in contributing to open-source projects in the future, there was no noticeable difference in male and female levels of interest; but when asked how likely they were to contribute in the future, female respondents reported feeling significantly less likely than male respondents to contribute code on GitHub in the future. While online developer communities can be valuable tools for skill development and recruitment, the lower rates of female participation suggest that women may not yet be reaping the benefits of these platforms. As a result, gender gaps in online developer communities may exacerbate existing gender gaps in ICT occupations.

3.2.3.3 / Faculty and researchers

There is surprisingly little publicly available and internationally comparable data on the proportions of women faculty employed in STEM or ICT-related academic programs. Possibly the most extensive source of substitutable data is the UNESCO Institute for Statistics' (UIS) data on female researchers, mostly in European countries.[11] The National Science Foundation (NSF) also collects detailed information on workforce participation of college graduates in the U.S. Statistics on other parts of the world are sparse and often dated, such as a 2015 USAID report presenting statistics on the leaky STEM academic pipeline in Africa dating back to 2008 (Cummings, 2015). This section presents UIS data on the proportion of female science and technology researchers as well as research on women faculty in STEM-related programs and business schools. Other potentially relevant data — such as women's share of research and development personnel and technicians — are unfortunately not systematically reported.

Researchers. As reported by the European Commission (2015), female researchers have been consistently underrepresented in Engineering and Technology, unlike other STEM fields such as the Medical Sciences. OECD (2017) research also finds that the proportion of women ICT specialists consistently lags behind the proportion of men, in all OECD communities. Figure 3.6 shows that the share of female researchers in the Engineering and Technology category ranges from 6% to 47%. While a few countries report that they are close to achieving equal participation of women (Malaysia, the Philippines, Kazakhstan, and Mongolia), most other countries are below 30%. Regional averages range from 22% to 29% for Engineering and Technology, as compared to between 34% and 50% for all other fields. At the country level, there is wide variation, from 30% to 55%. Trend data is uninformative, as the data available each year often represents different countries. [12]

Figure 3.6
Percentage of female researchers in engineering & technology (2010–15)



Source: UNESCO UIS

11 *UIS defines a researcher as a professional engaged in the conception or creation of new knowledge (UNESCO Institute for Statistics, 2017, p. 1).*

12 *For example, data is available for nine African countries in 2010 and a different set of three countries in 2015.*

STEM Faculty. Most of the studies carried out in North America and Europe show low proportions of women faculty in some STEM fields (often below 20%), particularly in fields related to engineering and computer science (e.g., Ling, 2017; Yoder, 2016). For example, workforce participation data from the 2013 National Science Foundation survey of doctorate recipients shows that, although women make up an equal proportion of United States graduates employed in science and engineering-related occupations in universities, they constitute only 34% of science and engineering occupations overall, and even fewer (17%) of computer and information scientists (https://www.nsf.gov/statistics/srvydoctoratework/).

Understanding the data from disparate research can be challenging; results may be contradictory or require nuanced interpretation. For example, Shauman (2017) found that women STEM graduates were more likely than men to enter tenure-track faculty positions within two years of degree completion, and equally likely to get such positions at research-intensive universities. However, while women were more likely than men to have jobs that require a doctorate, they were less likely to have research-oriented jobs. Furthermore, women graduates in engineering, mathematics, and computer science were less likely than other STEM graduates to work in business and industry. A controversial study by Ceci and Williams (2015) concluded that "women have substantial advantage in STEM faculty hiring, except when competing against more-accomplished men". Another study (Way, Larremore, & Clauset, 2016) found that hiring decisions in STEM departments were affected primarily by the productivity of candidates and the prestige of the candidates' academic institutions (although the authors also noted that subtle gender effects were probably at play).

A report by the Association of Academies and Societies of Sciences in Asia (AASSA, 2015) reviewed the state of women in science and technology in ten Asian countries, and found generally low representation of women in academic communities. In reference to Africa, Cummings (2015) laments the scarcity of robust data on women's representation in the STEM academic pipeline, noting that this hampers researchers' ability to provide a clear picture of the state of the academic pipeline in Africa:

The current inadequate data related to the underrepresentation of women faculty in STEAM careers undermines our capacity to provide adequate, scalable, replicable and sustainable solutions for gender inequalities. (Cummings, 2015, p. 3.)

Business School Faculty. Business schools represent an important context preparing individuals for leadership in both the corporate world and entrepreneurship. Analyses of the Global Salary Survey (a product of AACSB International, the Association to Advance Collegiate Schools of Business) indicate low proportions of women at leadership levels, shown in Table 3.4 (Brown, 2016). In 2017/18, 75% of deans and 66% of associate deans were men, and in 2015/16, just 20% of full professors were women (AACSB International, 2018).[13]

Table 3.4

Percentage of women faculty at business schools, by region

REGION	PROFESSORS	ASSOCIATE PROFESSORS	ASSISTANT PROFESSORS	INSTRUCTORS
Asia	13	27	38	50
Europe & near East	18	35	42	38
Middle East	13	21	25	47
Canada	23	34	41	39
US	28	31	29	42
Latin America and the Caribbean	20	33	37	40
All regions	20	33	38	40

Source: Adapted from Brown (2016).
Note: Based on 597 schools; no data for Africa and Oceania.

13 *Survey of 500 business school members of AACSB covering 25 countries, but primarily the U.S.*

3.3 / EMPLOYMENT–RETENTION AND ADVANCEMENT

Official statistics on retention rates are not collected at the global level. Evidence from North America and Europe indicates that women leave science and engineering jobs up to twice as frequently as men (Ashcraft, McLain, & Eger, 2016; Gumpertz, Durodoye, Griffith, & Wilson, 2017; J. Hunt, 2010). Most of this research, however, examines retention rates within the broad category of science and engineering, not the ICT industry specifically. Furthermore, much of the more recent literature on retention focuses on the reasons women leave the technology industry, rather than on their rate of leaving (e.g., Annabi & Lebovitz, 2018; Hunt, 2010; Servon & Visser, n.d.; Tapia & Kvasny, 2004). In Europe, Quirós et al. (2018, p.10) assert that attrition is especially high for women aged 30-40 years: "the prime working age and . . . the period when most Europeans have their first child and/or have to take care of their small children." Kahn and Ginther (2015) make a similar observation in their U.S. study. Research is needed to illuminate this topic, as much of what exists is limited in scale or scope and makes it difficult to compare churn rates for men and women technology workers, or across other types of industries. Reasons for attrition are contested; some researchers attribute it to family life demands, while others attribute it to workplace discrimination, including unequal pay, low access to advancement opportunities, dominant male culture, and unwelcoming environments. (This issue is further discussed in Chapter 4.)

According to the 2017 Global Gender Gap report (World Economic Forum, 2017), despite some gains since 2007, "every industry exhibits a leadership gender gap" and "the largest gaps are found in the STEM fields: Software and IT Services, Manufacturing and Energy and Mining" (p. 32).[14] In the absence of global data on women managers and executives in the ICT industry, this section examines three metrics on women female leaders more generally: employment in management positions; employment in senior and middle management positions; and employment as chief executives, senior officials and legislators. It also briefly covers women in academia leadership and ICT management, drawing on scholarly and other literature.

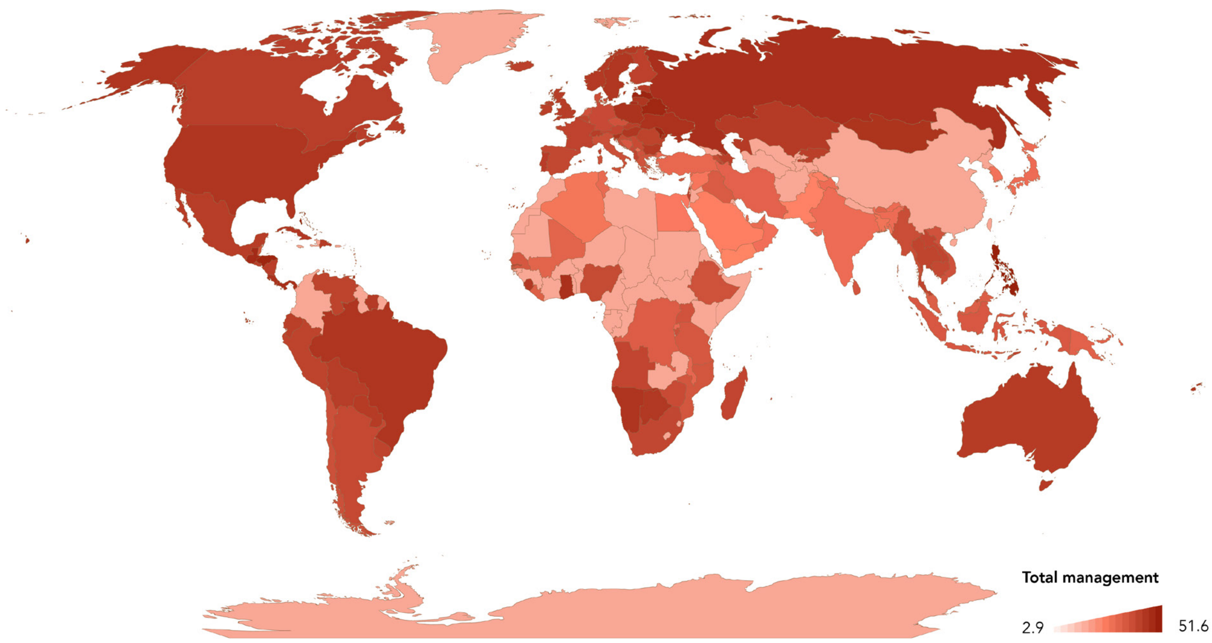
3.3.1 / GENERAL LEADERSHIP POSITIONS

While regional trends suggest that women's employment in leadership positions is below 40% for all countries, a few countries nevertheless report close to or above parity (Figures 3.7–3.9). Regional trends appear essentially unchanged since 2009, despite some changes in several countries. Thus, as with the indicators in the previous sections, these metrics are best examined at the country level.

Exploring the data on senior and middle management positions for the last known year, we see wide variability in all regions (Figure 3.8). In Africa, the percentage of women managers ranges from 4% (Mali) to 44% (Seychelles), with 12 reporting countries. For the two countries with multiple year data (Mauritius and Seychelles), there is a rising trend between 2011 and 2015 of about 9% for Seychelles and 6% for Mauritius. Out of 13 countries reporting from the Americas, Uruguay has the lowest proportion of women senior and middle managers (33.7%), while the Dominican Republic has the highest (47%). Yearly data for the Americas (2011–2014) shows the proportion of women rising in two countries, remaining the same in two countries, and falling in three countries. Similar variability is seen in Asia (with 15 reporting countries), where women's employment as senior or middle managers ranges from 4% (Pakistan) to 37% (Mongolia); the proportion is increasing in three countries, decreasing in four, and remains the same in two. Likewise, in Europe, the proportion of women increases in nine countries, decreases in 21 countries, and is stagnant in two countries. The variation in Europe for the last known year ranges from 14% (Kosovo) to 48% (Russia). Finally, in Oceania, the figures range from 33% (Australia) to 42% (Samoa); the only country with yearly data (Australia) shows a slight increase from 30% in 2010.

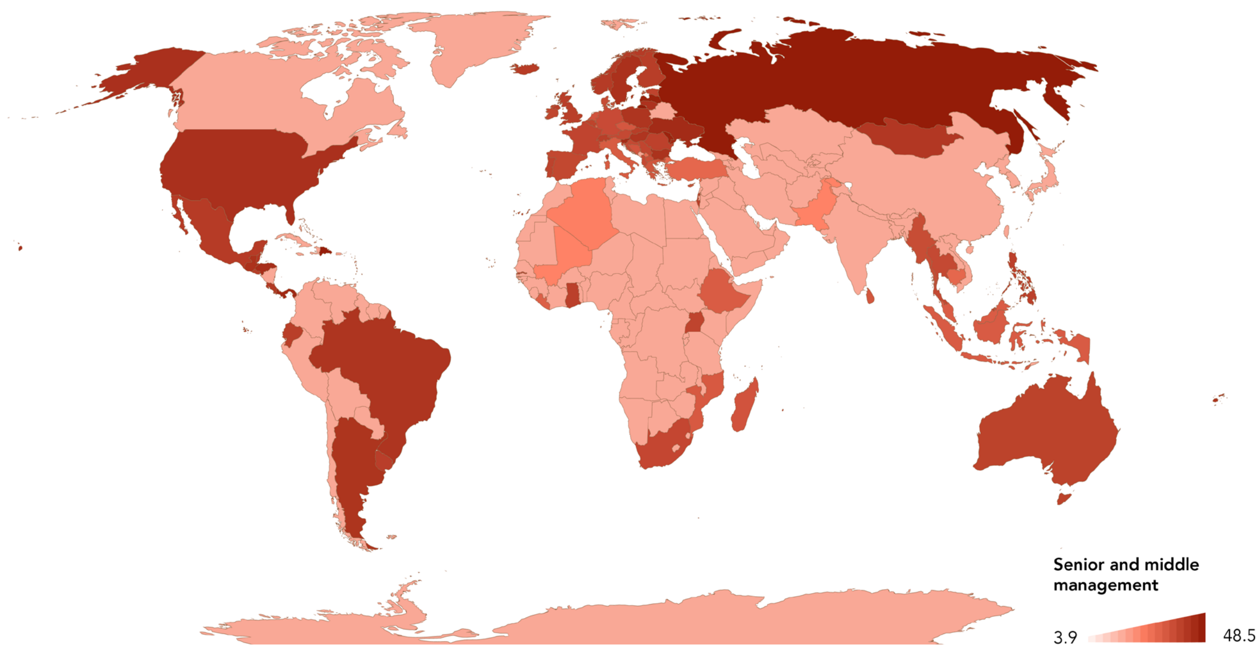
14 *Based on an analysis of LinkedIn data.*

Figure 3.7
Female share of employment in managerial positions – Total management



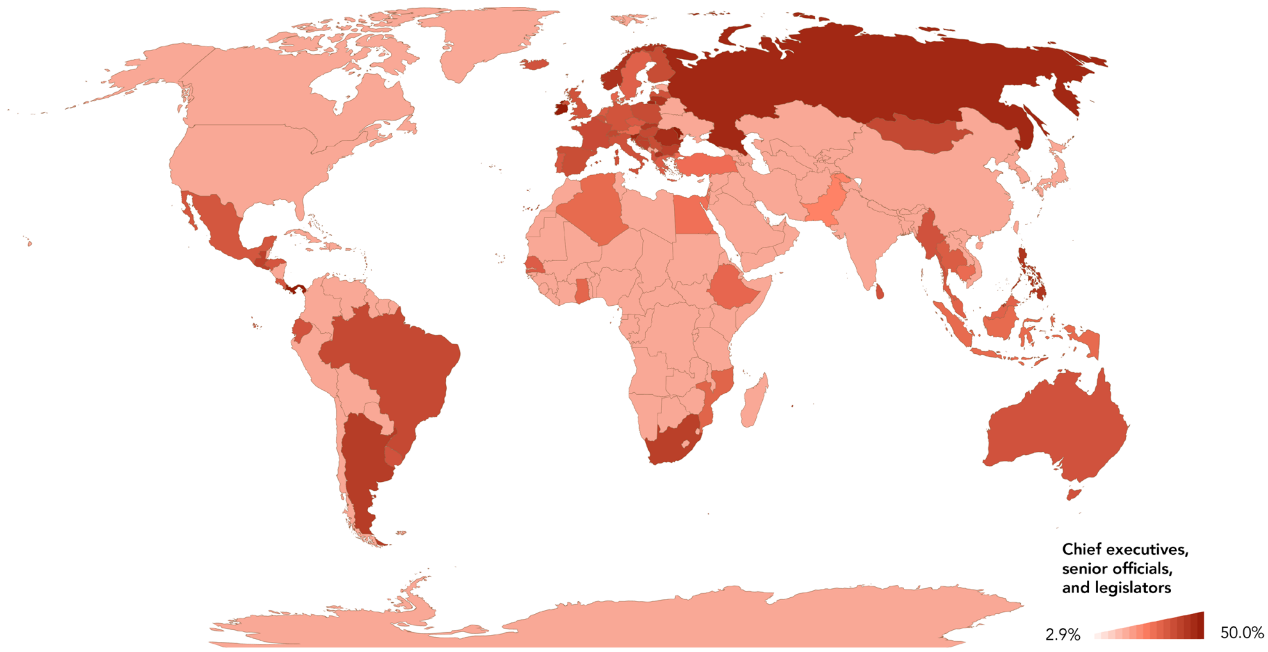
Source: ILOSTAT

Figure 3.8
Female share of employment in managerial positions – Senior & middle management



Source: ILOSTAT
Note: Limited data from most countries. For example, number of economies reporting for 2016: Africa 2; Americas 7; Asia 9; Europe 32; Oceania 2.

Figure 3.9
Female share of employment as chief executives, senior officials and legislators



Source: ILOSTAT

3.3.2 / LEADERSHIP POSITIONS IN THE ICT INDUSTRY

Data for the ICT industry is even less available than for general management trends. The most readily available data tends to come from a few national statistics departments. Other insights can be obtained from market research conducted by private organisations (which is often not freely available), and from academic research (addressing relatively narrow contexts). This section reviews examples of these studies covering three areas: the telecommunications industry, academies of science, and board membership. The variation in management levels, job titles, and business sectors sampled by various researchers limits the comparability of studies.

Telecommunications. A GSMA study of gender diversity in 54 telecom companies (Molina et al., 2015) showed that in all regions, women were employed in much larger proportions as entry-level staff rather than in middle and senior management positions. The largest gap was in Africa and the smallest in North America (Table 3.5). As with our observations on gender diversity in general management, the trends appear to be shifting, though from such a low level that the gap remains large. For example, the Global Telecoms Business lists the 100 most powerful people in the industry; it included 14 women in 2017 — up from only six in 2016, but still representing just 14%.

Table 3.5
Percentage of female telecom company employees

	ENTRY LEVEL	MIDDLE MANAGEMENT	SENIOR MANAGEMENT
Africa	35	21	9
Middle East	26	19	13
Asia-Pacific	28	19	15
Europe	43	30	20
North America	40	37	31

Source: Molina, Lin & Wood, 2015, p. 13.

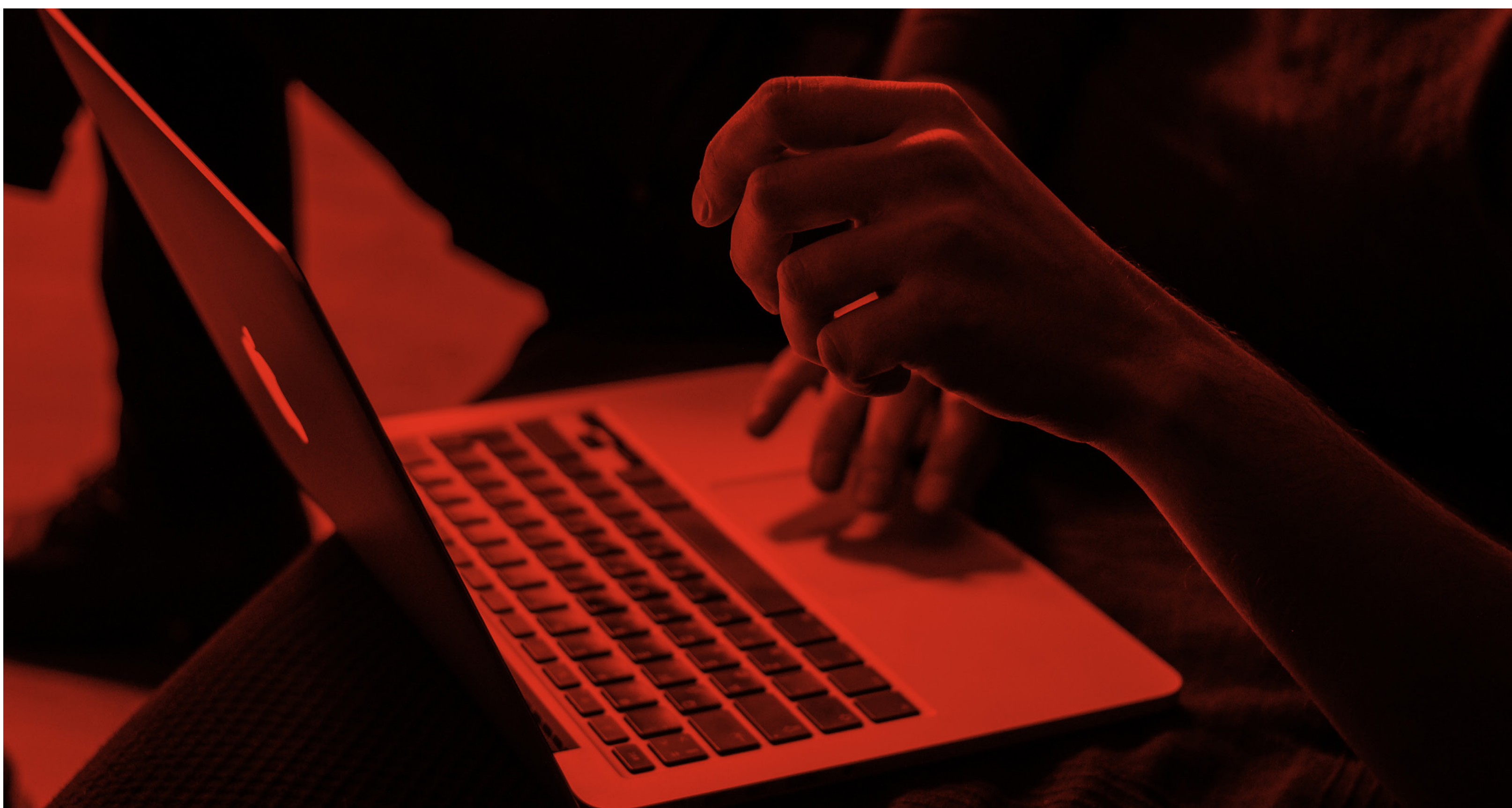
IT Sector. Examining the European landscape, Quiros et al. (2018, p. 13) report that in 2015 the IT sector was "the only sector without women occupying CEO positions in any of the corporations in STOXX 600." Women held 9.5% of CEO positions in the Telecom Services sector; only 25% of workers in the ICT sector had women bosses, compared to 48% in non-ICT sectors. In a global study, Dawson et al. (2014, p. 3) concluded that women were more represented in senior management of "new economy" companies, although overall women tended to be in less influential management roles. Table 3.6 shows that the proportion of women senior managers in several technology-related sectors exceeds the global average — except at CEO level.

Table 3.6
Women in senior management – Technology companies

	CEO	Operations	CFO/ Strategy	Shared Services*	Total
Tech – hardware	3,4	3,4	17,3	8,5	7,1
Telecoms	4,9	9,8	18,3	24,2	15,4
Tech – other	0	8,2	22,5	42,1	16,4
Tech – software	3,3	18,9	17	31,6	19,5
Global Average	3,9	8,6	17,5	18,9	12,9

Source: Dawson et al., 2014, p. 15.
Note: * HR, Legal, IT, External Relations

Data from the U.S. Bureau of Labor Statistics indicates that women currently make up about 29% of Computer and Information Systems managers. Similarly, the Equal Employment Opportunity Commission (2016) found that women comprised 20% of Executives, Senior Officials, and Managers in the high-tech industry in 2014. This percentage had not changed much by 2015; the U.S. Government Accountability Office (2017) reports that women occupied 19% of senior management positions in technology sector companies, and that this has essentially been unchanged since 2007. Bell and White (2014), on the other hand, conclude that progress has been made towards having more women in top positions over the past two decades, although they are still underrepresented. Overall, women tend to be in junior and support rather than managerial roles. Where women have made inroads into management, they are often in staff positions, rather than the line positions which constitute the main pathway to executive roles (Molina, Lin & Wood, 2015; United States Government Accountability Office, 2017; World Economic Forum, 2017). These trends appear to be repeated in the new industries developing around artificial intelligence (Case study 3.2; Parsheera, 2018).



Case Study 3.2

Where are the women? Gender disparities in AI research and development

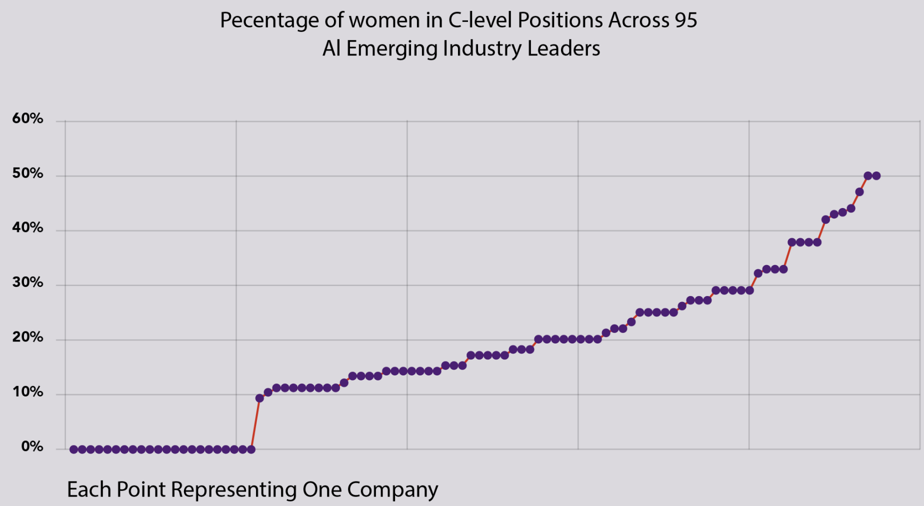
Author: Mike Best & Dhaval Modi (UNU-CS)

The artificial intelligence (AI) community has a diversity problem. Kate Crawford, a Microsoft researcher and NYU professor, asserts that AI has a "white guy problem" (Crawford, 2016). She explains why this matters: "Like all technologies before it, artificial intelligence will reflect the values of its creators. So inclusivity matters. . . . Otherwise, we risk constructing machine intelligence that mirrors a narrow and privileged vision of society, with its old, familiar biases and stereotypes."

The low level of female presence among AI researchers, developers, and thought leaders epitomises this diversity challenge. Hannah Wallach, a Microsoft-based AI researcher and founder of Women in Machine Learning (WiML), estimates that the entire field of machine learning is only 13.5% female (Weissman, 2016). To better amass evidence as to this gender disparity, we have accumulated data on women participation in leadership among top AI companies, as well as scholarly presence among the top U.S.-based university computer science faculty.

To calculate the percentage of women in executive management at leading AI startups, we began with CB Insights' 2018 "AI 100", their ranking of the top 100 promising start-ups in Artificial Intelligence (https://www.cbinsights.com/research/artificial-intelligence-top-startups/). CB Insights' 2018 "AI 100" list includes companies from the U.S., Canada, the UK, France, Spain, Japan, China, Taiwan, and Israel (https://www.cbinsights.com/research/artificial-intelligence-top-startups/). We were able to establish the gender balance among executive management for 95 of these companies. (One C-level manager is identified as non-binary and is not categorised here.) Only two companies have equal numbers of women and men in their C-level positions and none are majority female. Three in five have less than 20% women in their leadership team, and one in five have no females at all. Women overall made up 18% of these AI leaders.

Figure 3.10
Women in senior management – Technology companies



Source: Dawson et al., 2014, p. 15.
Note: * HR, Legal, IT, External Relations

We computed the percentage of female professors at top U.S.-based university AI programs, based on the top 20 programs listed in the US News & World Report 2018 ranking of best artificial intelligence graduate programs (https://www.usnews.com/best-graduate-schools/top-scienceschools/artificial-intelligence-rankings). We calculated the number of faculty members (including adjuncts) from each university's website and from laboratory staff listings (e.g., for Stanford University), as well as from research interests as stated on faculty websites (e.g., Carnegie Mellon).
We were able to obtain faculty gender information for all but two programs (UCLA and Cal Tech). The average percentage of female AI faculty was 22%, ranging from 8% (University of Pennsylvania) to 43% (Harvard). No university had achieved gender parity among its AI faculty.

3.3.3 / LEADERSHIP ON BOARDS

A similar trend of low representation of women is seen with board membership (Deloitte & Alliance for Board Diversity, 2016; Institutional Shareholder Services, Inc & Regulation, 2017; Quirós et al., 2018). However, it is unclear whether the situation is worse in the ICT industry than in other areas. Some data are difficult to interpret, due in part to varying definitions and the diversity of industry sectors. Adams and Kirchmaier (2016) studied data for listed firms in 20 countries and found that firms in STEM and Finance sectors had 1.8% fewer women on boards than firms in non-STEM sectors. In cybersecurity, men are four times more likely than women to hold executive-level positions, and nine times more likely to hold managerial positions (Frost & Sullivan, 2017). Women comprise 9% and 15% respectively of directors and executive officers in Canada's technology industry (MacDougall et al., 2017), while according to Bell (2016), Silicon Valley firms have relatively low proportions of women directors, at 14% (compared to 23% for large public companies).

Conversely, Chanavat and Ramsden (2013), evaluating multiple countries, found that technology companies had some of the most gender-diverse boards (around 20% women), but that telecommunication service companies had less diverse boards (around 15%). In Europe, however, the telecommunication service sector has the highest percentage of women on boards (at 27%) and "is also the only sector where all companies have at least one woman on their boards"(Quirós et al., 2018, p. 12). Quiros et al. (2018) also found significant improvement in the number of women board members in the IT industry — a 102% increase since 2011 — although the IT sector also had the highest percentage of all-men boards. A global study by Credit Suisse (Dawson et al., 2014) found that the telecom industry had one of the highest proportions of women on boards, while the technology industry had lower proportions (Table 3.7). Comparing women on boards in a variety of economic sectors, Deloitte (2017) found that, while in most regions the Technology, Media and Telecoms category was not among the top three performers, in Asia and the Middle East women constituted 8% and 12% (respectively) of boards in this category.

Table 3.7
Percentage of women on boards, by industry

	2010	2013	0	<10%	10% - 20%	20% - 30%	>30%
Technology	8,1	10,9	40,8	7,9	32,1	15,8	3,4
Telecoms	11,1	14,2	34,1	12,2	22	20,7	11
Total	9,6	12,7	33,7	11,1	31,4	16,9	6,9

Source: Dawson et al., 2014, p. 10.

These mixed findings complicate any analysis of gender equality in board membership of ICT companies. Furthermore, board size impacts diversity as well, as the boards of larger companies tend to be more gender diverse than those of smaller and younger companies (Bell, 2016; Brush, Greene, Balachandra, & Davis, 2014). This suggests that understanding and measuring board diversity may require more than simple headcounts.

3.3.4 / ACADEMIES OF SCIENCE

Analysis of data from the European Institute for Gender Equality (EIGE) shows that in the 28 EU member states, women comprise less than 22% of membership and less than 16% of presidents or chairs of the highest decision-making body in national academies of science (EIGE database, 2017)[15]. Only eight countries have women presidents or chairs. Similar trends likely pertain elsewhere; a survey by the Academy of Science of South Africa (2015) finds that, globally, women make up only about 12% of the membership of science academies. The highest proportion was at the Cuban Academy of Sciences (27%) and the lowest at the Polish and Tanzanian Academies of Sciences (4% each). Women constitute 12% of elected Fellows of The World Academy of Sciences (TWAS)[16] and 32% of its Young Affiliates programme (The World Academy of Sciences, 2018). As Table 3.8 shows, the distribution of women TWAS fellows across different disciplines mirrors the tendency for women science scholars to be concentrated in the medical and social sciences.

Table 3.8
The World Academy of Sciences Fellows

FIELD	NUMBER OF FEMALES	NUMBER OF MALES	PERCENTAGE OF FEMALES
Social & economic sciences	12	32	27%
Medical & health sciences including neurosciences	30	124	19%
Structural cell & molecular biology	21	116	15%
Agricultural sciences	18	85	17%
Biological systems & organisms	14	70	17%
Chemical sciences	16	142	10%
Astronomy, space and earth sciences	15	117	11%
Physics	14	167	8%
Mathematical sciences	7	106	6%
Engineering sciences	5	112	4%

Source: The World Academy of Sciences, https://twas.org/directory/overview

15 *Note: out of 58 positions. Most countries have just one leadership position per academy, but may have several academies.*

16 *A "global science academy dedicated to building science in the developing world" (TWAS website), with membership from 100 countries.*

3.4 / ENTREPRENEURSHIP

While some of the issues women face in the ICT employment realm may also apply to their participation in digital entrepreneurship, other issues are unique to women entrepreneurs. Access to venture capital is one that has received considerable attention in recent months, as data reveals how little such capital is available to women entrepreneurs. However, there is still limited data on this and other relevant issues (Kuschel & Lepeley, 2016). Thus, we use indicators relating to women entrepreneurship broadly, with a few additional sources about the ICT industry. The discussion below covers women's participation in ownership of businesses, access to business training, and access to business capital.

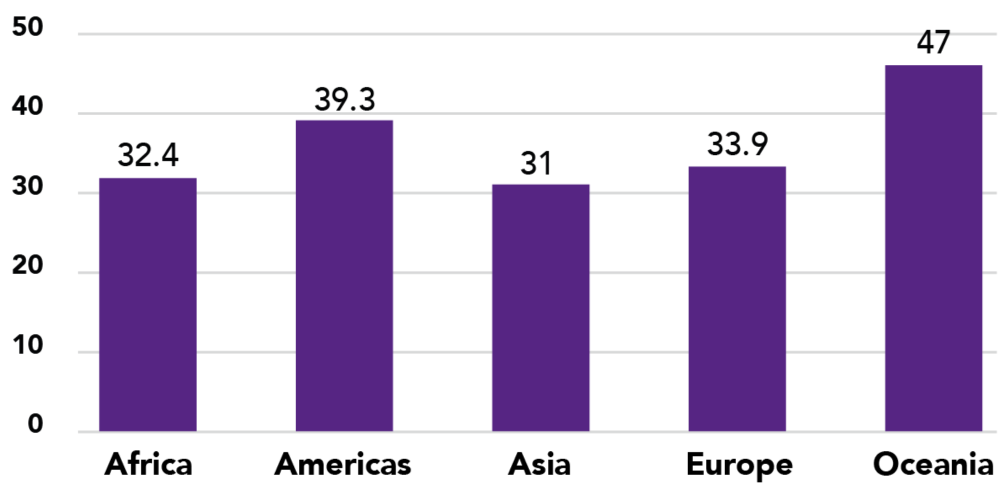
3.4.1 / FIRM OWNERSHIP

Globally, the gender gap in entrepreneurship has narrowed since 2014; however, women are less likely than men to start enterprises in the ICT sector (Kelley et al., 2017). Women constitute only 6% of information technology entrepreneurs in the U.S. (Gompers & Wang, 2017b); Europe has a higher proportion of women entrepreneurs in the ICT industry, at 23% (Quirós et al., 2018).

The data presented below relates to women's participation in ownership of firms in general, in the absence of global data on women's ownership of technology or ICT firms. (Note, however, that relatively few countries report even this data: 10% of countries in Oceania, 47% in Europe, 61% in Africa, 64% in Asia, and 65% in the Americas.) The available data shows that less than 50% of firms have at least one woman owner (Figure 3.11). Data collected by the Global Entrepreneurship Monitor (2015 dataset) shows a higher proportion of men entrepreneurs in most countries. That entrepreneurial gender gap ranges from 5% in the Philippines — where women are more likely than men to be engaged in entrepreneurial activity — to -11% in Lebanon, where men are more likely than women to be engaged in entrepreneurial activity. Women exhibit more entrepreneurial behaviour than men in six countries, of which five are in Asia.

At the country level, we see an entrepreneurship paradox similar to the education paradox mentioned in Chapter 2: the lower a country's level of socio-economic development, the smaller the gender gap in entrepreneurship seems to be.[17] However, women entrepreneurs in lower-income countries are more likely to be driven by necessity rather than opportunity motives (Kelley et al., 2017; OECD, 2012), and this can compromise the long-term sustainability and growth of their ventures. There is also insufficient data to determine whether women venture into digital entrepreneurship. Some evidence suggests that the digital economy has generated opportunities (such as airtime sales, phone repairs, data entry, community information services, and call centres) for women entrepreneurs in developing countries; see, for example, Heeks (2005) and UNCTAD (2014). However, more data is needed to determine the relative proportion of men to women in these enterprises, and whether there are differences in the conditions under which they work.

Figure 3.11
Percentage of firms with women participating in ownership



Source: World Bank.
Note: Variable data availability for different regions.

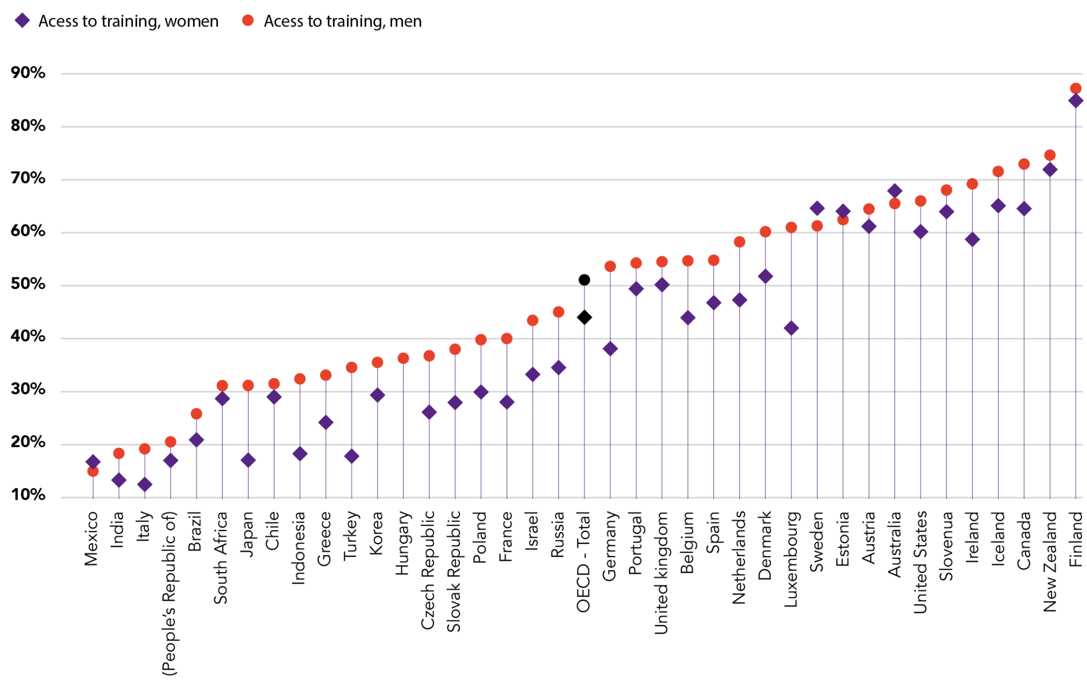
17 *The reasons for this are beyond the scope of this report, but some relevant factors may be found in the entrepreneurship literature.*

3.4.2 / ACCESS TO BUSINESS TRAINING

Most discussions of gender gaps in ICT entrepreneurship tend to approach the subject from the perspective of access to the appropriate technical training, with less attention being paid to obtaining the requisite business skills. Most ICT entrepreneurs require business knowledge to be successful in running the enterprise and, importantly, to raise business capital. Indeed, an interest in business —instead of an interest in technology — represents an alternative route to digital entrepreneurship.

OECD data indicates that women generally have less access than men to training on how to start a business (Figure 3.12). The tendency is the same in the six non-OECD economies included in the dataset. Only in four countries (Mexico, Estonia, Australia, and Sweden) are women equal to or slightly more advantaged than men with regard to such training. The gap is highest in Luxemburg (19% more men) and lowest in Sweden (3% more women).

Figure 3.12
Access to training to start a business



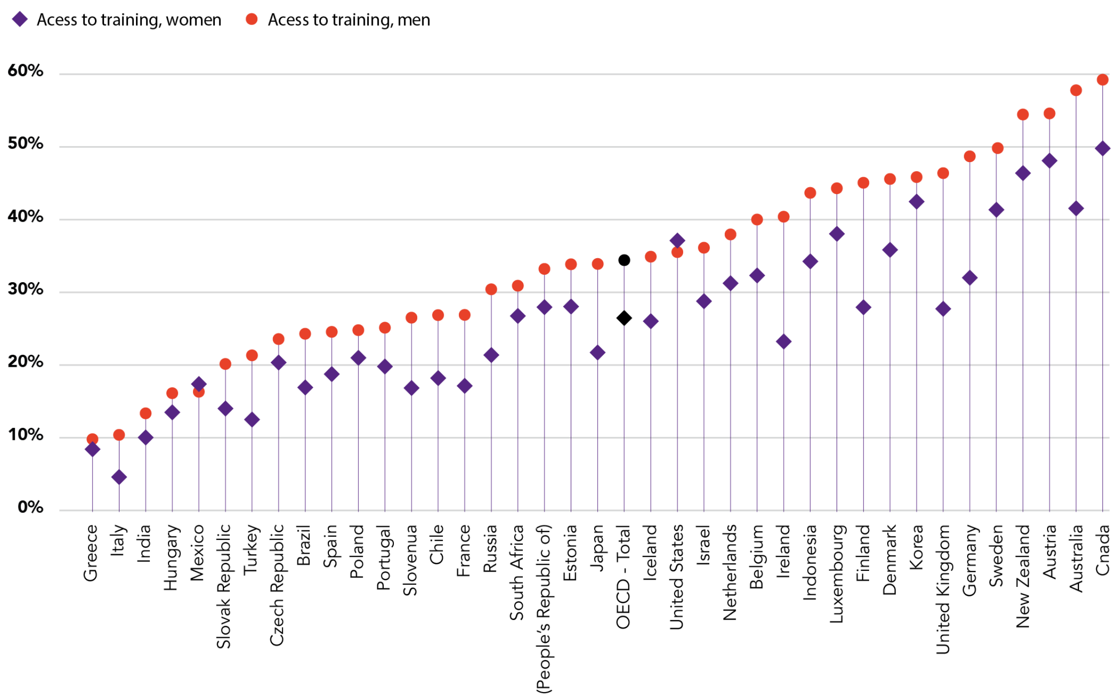
Source: OECD Social and Welfare Statistics, 2018 (database), http://dx.doi.org/10.1787/data-00723-en

3.4.3 / ACCESS TO BUSINESS CAPITAL

Access to capital is critical for entrepreneurs, regardless of business size. Some indication of ability to secure capital can be gleaned from data on the use of formal financial instruments by the general population. This section presents OECD data, on access to capital to start a business, as well as World Bank data, on ownership of a bank account, saving, and borrowing from a financial institution.

Overall, women are disadvantaged in access to financial services that could facilitate access to business capital. In most OECD countries, women are less likely to have access to capital to start a business compared to men (Figure 3.13).

Figure 3.13
Access to finance to start a business

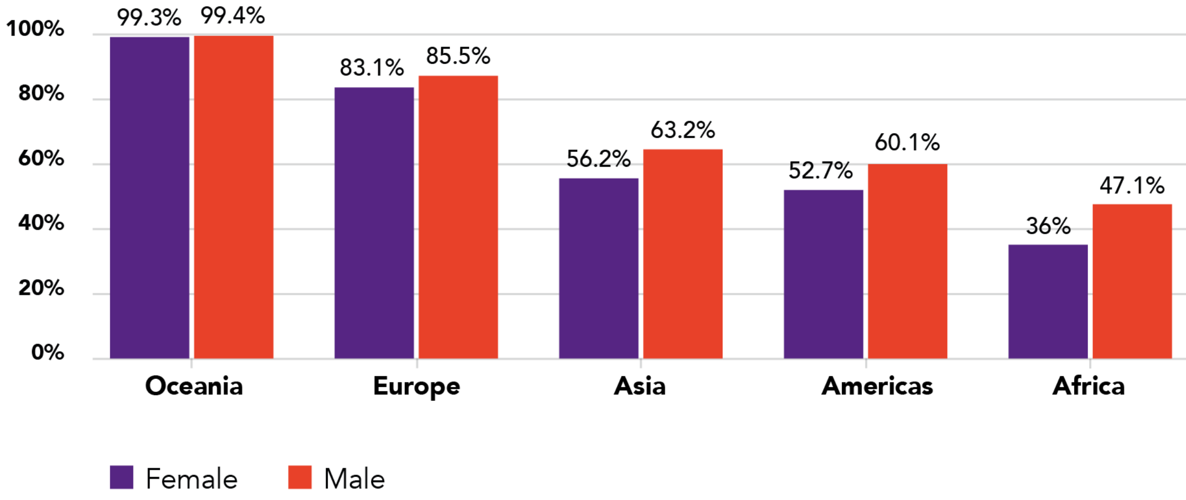


Source: OECD Social and Welfare Statistics, 2018 (database), http://dx.doi.org/10.1787/data-00723-en

Levels of financial inclusion are low for both men and women in Asia, the Americas, and Africa. Even so, all regions except Oceania exhibit a gender gap in favour of men, though very narrow in some cases (Figures 3.14–3.16). The gap in account ownership ranges from 2% (Europe) to 11% (Africa). The gap in saving activity ranges from 3% (Asia) to 5% (Americas). And the gap in borrowing activity ranges from 2% (Africa) to 3% (Europe). In the two Oceania countries represented, women have equal access to bank accounts, they are more likely to save than men, and they are more likely to have borrowed from a financial institution. Globally, a pilot survey of 28 central banks and other regulators found that 40% of account holders and borrowers are women (IMF, 2018).

Figure 3.14

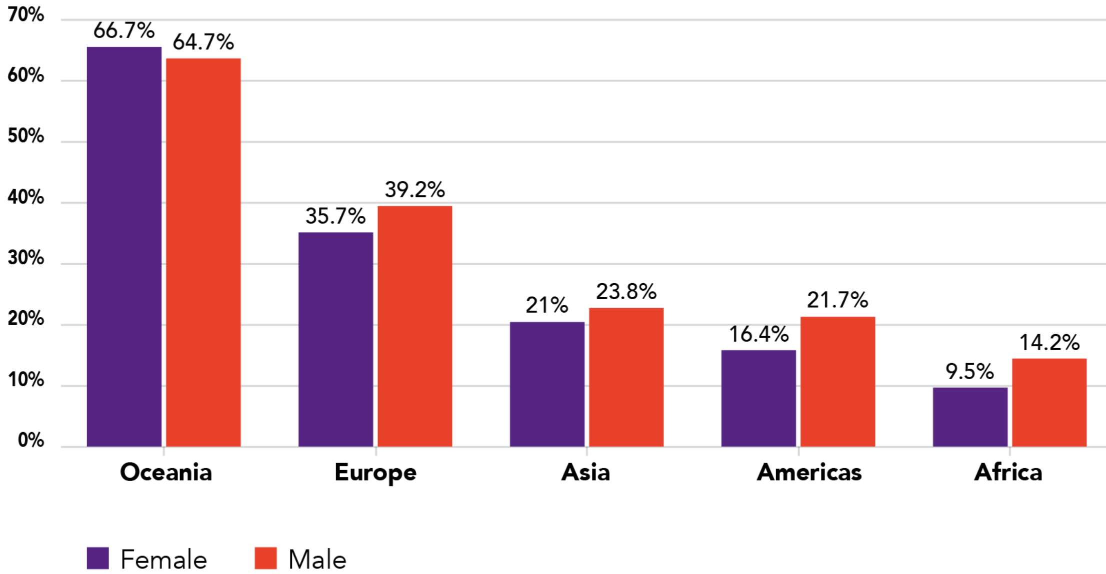
Percentage of adults (15+ years) with an account at a bank or other financial institution or with a mobile-money-service provider



Note: Robust data – 144 countries represented; only 2 countries from Oceania.

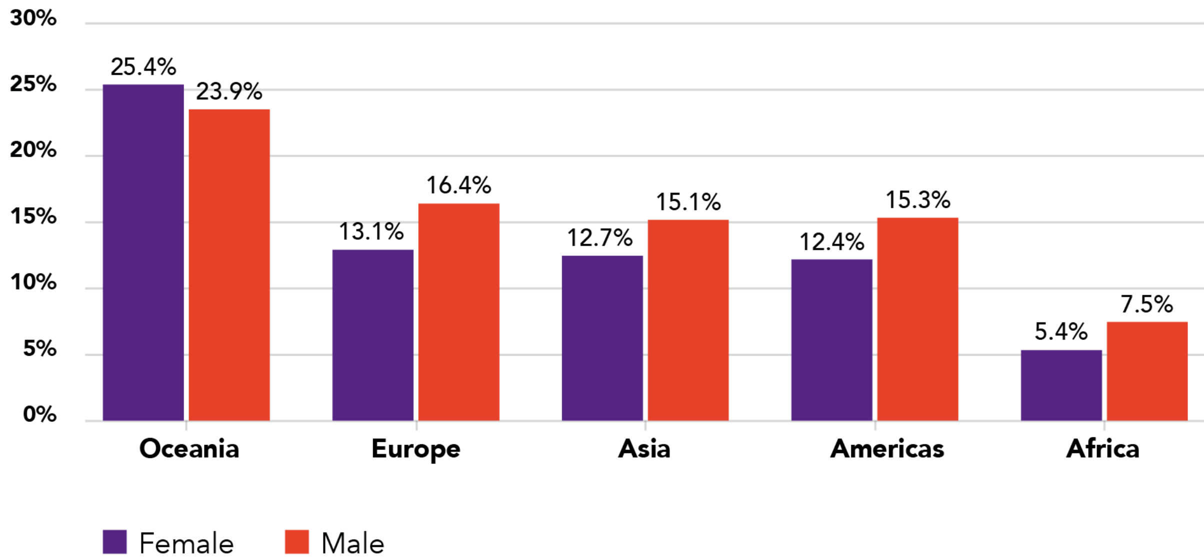
Figure 3.15

Percentage of adults (15+ years) who have saved at a financial institution



Source: World Bank, Global Findex Database (http://www.worldbank.org/globalfindex).
Note: Robust data – 144 countries represented; only 2 countries from Oceania.

Figure 3.16
Percentage of adults (15+ years) who have borrowed from a financial institution



Source: World Bank, Global Findex Database (http://www.worldbank.org/globalfindex).
Note: Robust data – 144 countries represented; only 2 countries from Oceania.

3.4.4 / ACCESS TO VENTURE CAPITAL

The availability of venture capital (VC) investment provides a view on the experience of women trying to start ventures in the ICT industry, since a majority of venture capital goes into the ICT and related sectors (Ernst & Young, 2015). The U.S. (and especially the San Francisco Bay area) receives almost three-quarters of global venture capital (Ernst & Young, 2015), and a majority of this goes to the software (36%) and biotechnology (17%) sectors (NVCA, 2016).

Data on entrepreneurs' access to venture capital is only recently becoming public. It shows that investment in businesses with women partners has increased but still remains low, and women-run companies receive a dismal proportion of venture capital. Brush et al. (2014) examined a database of 6,793 VC recipients in the U.S. between 2011 and 2013 and found that over 15% of the companies had a woman on the executive team, up from less than 5% in 1999. Moreover, the companies with a woman on the team also received more funding than in previous years. However, only 2.7% of the companies had a woman CEO, and those companies only received 3% of total VC investments (see also: Bradley, Gicheva, Hassell, & Link, 2013; and Scott, Kapor Klein, McAlear, Martin, & Koshy, 2018). A study of 58 investment funds that ascribe to gender-lens investing found, on the positive side, that 59% of these funds had all-women partners (compared to the industry norm of 7%). However, they also noted "an inverse relationship between fund size and the proportion of women fund partners or investment committee members: the more women at the top, the less capital raised" (Biegel, Hunt, & Kuhlman, 2017, p. 6). Similarly, Quiros et al. (2018) observed that in Europe, wholly woman-owned startups received less than 5% of all VC deals in 2016 — an improvement over previous years — and that in the UK, for example, men entrepreneurs were 86% more likely to obtain VC funds than women (p. 12).

A lack of diversity can also be seen within venture capital firms, with very few woman venture capitalists. For example, a review of 160 venture capital firms in the UK found that only 13% of partners were women; 48% of investment teams had no women (Diversity VC, 2017). Likewise, Scott et al. (2018) report that women constitute just 11% of investment professionals in the U.S. This is important if, as some evidence suggests, VC firms with women partners are more likely to invest in businesses with women managers or CEOs, compared to VC firms with women in their management teams (Brush et al., 2014).

3.5 / POLICYMAKING

The dearth of gender perspectives in the technology industry could potentially be addressed by including more women in senior policymaking positions, not only in technology organisations but also in political institutions.

3.5.1 / PARTICIPATION IN NATIONAL GOVERNANCE

At the level of national governance, gender diversity is already low, as seen in the proportion of seats held by women in national parliaments (Table 3.9). All regions have less than 30% representation of women.

Table 3.9
Proportion of seats held by women in national parliaments

	SINGLE HOUSE OR LOWER HOUSE	UPPER HOUSE OR SENATE	BOTH HOUSES COMBINED
Americas	28,8	29,5	28,9
Europe	27,6	27	27,5
Sub-Saharan Africa	23,9	23,1	23,8
Asia	19,7	17,5	19,5
Arab States	18,5	12,6	17,7
Pacific	15,5	37,1	17,9

Source: Inter-Parliamentary Union, April 2018, http://archive.ipu.org/wmn-e/arc/world010418.htm

3.5.2 / PARTICIPATION IN ICT-RELATED POLICYMAKING AGENCIES

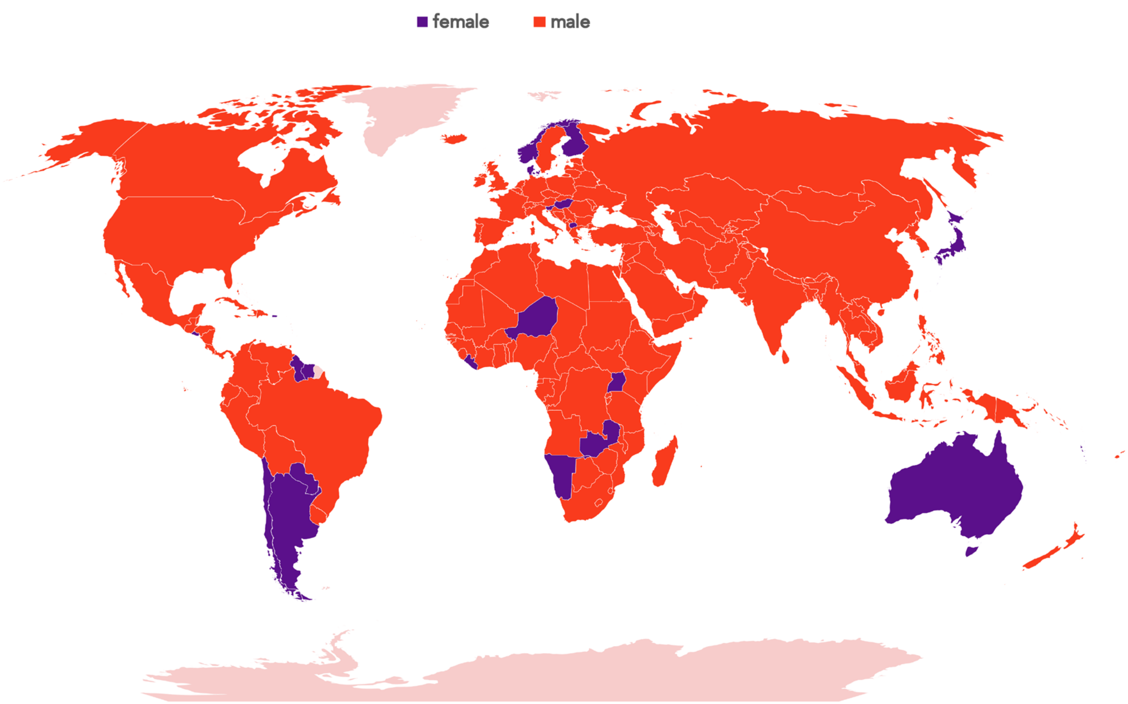
Public information is available relating to two key types of ICT-related government agencies — ICT ministries and telecommunications regulators. Worldwide, only 28 out of 203 countries have a woman in charge of the ICT ministry (Table 3.10). Nearly 88% of ICT ministers are men (Figure 3.17). Africa and the Americas have the highest percentage of ICT ministries led by a woman (17% and 23%, respectively).

Table 3.10
Proportion of female heads of policymaking agencies

	ICT MINISTRY	TELECOM REGULATOR
Americas	20%	23%
Africa	14%	9%
Europe	13%	13%
Oceania	7%	23%
Asia	2%	6%
TOTAL	12%	13%

Source: UNU-CS desk research, June 2018

Figure 3.17
Countries with a woman in charge of the ICT ministry

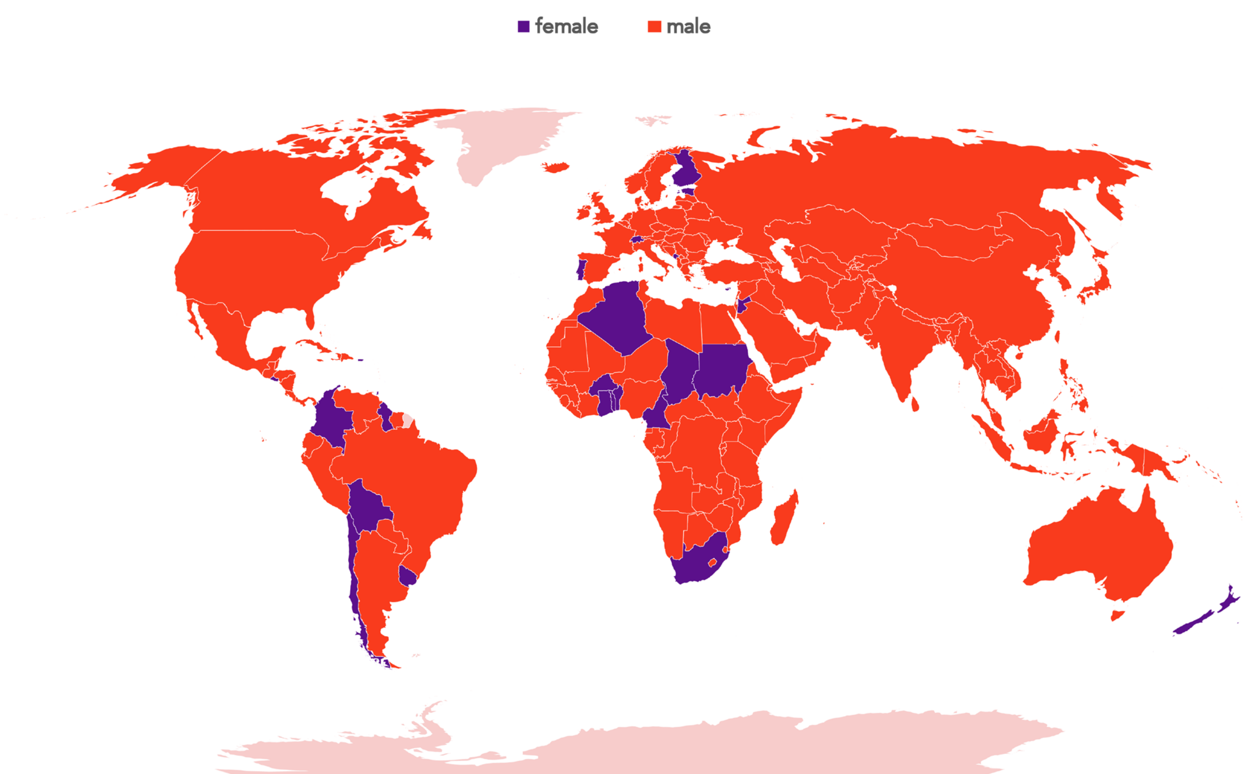


Source: UNU-CS desk research, June 2018

The 28 countries with a woman ICT minister in 2018 were: Algeria, Barbados, Benin, Bolivia, Burkina Faso, Cameroon, Chad, Chile, Colombia, Cyprus, El Salvador, Estonia, Finland, Ghana, Guyana, Jordan, Monaco, Montenegro, New Zealand, Portugal, Puerto Rico, Sint Maarten, South Africa, Sudan, Switzerland, Togo, Trinidad and Tobago, and Uruguay.

Similarly, in 2018, only 25 countries had a woman heading the telecommunications regulator (Figure 3.18). The Americas and Oceania have the highest percentage of woman telecommunication regulators (23% in each region). The 25 countries with a woman as head of the telecommunications regulator were: Argentina, Australia, Chile, Denmark, El Salvador[18], Finland, Guyana, Hong Kong, Hungary, Japan, Liberia, Macau, Macedonia, Namibia, Niger, Norway, Paraguay, Puerto Rico[19], Samoa, Sint Maarten, Slovenia, Suriname, Uganda, Vanuatu, and Zambia.

Figure 3.18
Countries with a woman in charge of the telecommunications regulator



Source: UNU-CS desk research, June 2018.

18 *The head of El Salvador's telecommunications regulator is also the Minister of Communications and Information Technology (ICT).*

19 *The head of Puerto Rico's telecommunications regulator is also the Minister of Communications and Information Technology (ICT).*

3.6 / CONCLUSION

This chapter reviewed data and research on women's employment in the ICT workforce, women's contribution to the industry as entrepreneurs, and women's inclusion in related policymaking. The results suggest that, although gains have been made over the years, women's representation is low across different dimensions. While more and more women are holding highly skilled jobs, few of them are in ICT-related fields; however, we see wide variation by country. Within ICT and STEM occupations, women are nearly absent from software development, in engineering and technology research, and in university teaching. There is a high rate of women leaving science and technology jobs, whether due to the lack of work-life balance frequently found in male-dominated fields or to a range of gendered obstacles to achieving their career goals. Few women are found at any level of technology leadership, and those tend to serve in subordinate roles with little chance for advancement. Women are also less likely to become ICT entrepreneurs; they generally lack training in business startups and have very little access to venture capital. Most seriously, they have a very low rate of representation in science and technology policy making.

However, the severe lack of relevant data makes it difficult to reach an accurate assessment of the global situation. European and North American countries tend to have the most ICT-specific data; and even there, the data is variable and often requires nuanced interpretation.

REFERENCES

AACSB International. (2018). Staff compensation and demographics report: 2017-18 executive summary. Association to Advance Collegiate Schools of Business. Retrieved from: https://www.aacsb.edu/-/media/aacsb/publications/data-reports/global-salary-survey/staff%20compensation%20and%20demographics%20report%202017-18%20executive%20summary.ashx?la=en

AASSA. (2015). Women in science and technology in Asia. The Association of Academies and Societies of Sciences in Asia. Retrieved from: www.interacademies.org/File.aspx?id=28016

Adams, R. B., & Kirchmaier, T. (2016). Women on Boards in Finance and STEM Industries. American Economic Review, 106(5), 277–281. Retrieved from: https://doi.org/10.1257/aer.p20161034

Annabi, H., & Lebovitz, S. (2018). Improving the retention of women in the IT workforce: An investigation of gender diversity interventions in the USA. Information Systems Journal, 0(0). Retrieved from: https://doi.org/10.1111/isj.12182

Ashcraft, C., McLain, B., & Eger, E. (2016). Women in tech: The facts (p. 76). National Center for Women & Technology (NCWIT).

BCS. (2017). Diversity in IT 2017. Swindon: BCS, The Chartered Institute for IT. Retrieved from: http://www.bcs.org/category/19217?src=hs4

Bell, D. (2016). Corporate Governance Practices and Trends: A Comparison of Large Public Companies and Silicon Valley Companies. Retrieved from: https://www.fenwick.com/FenwickDocuments/2016-Corporate-Governance.pdf

Bell, D., & White, S. S. (2014). Gender Diversity in Silicon Valley: A Comparison of Silicon Valley Public Companies and Large Public Companies. Retrieved from: https://www.fenwick.com/FenwickDocuments/Gender_Diversity_2014.pdf

Biegel, S., Hunt, S. M., & Kuhlman, S. (2017). TRACKING VENTURE CAPITAL WITH A GENDER LENS (p. 36). Retrieved from: https://socialimpact.wharton.upenn.edu/wp-content/uploads/2017/10/ProjectSage-Report_10.25.17.pdf

Blau, F. D., Brummund, P., & Liu, A. Y.-H. (2013). Trends in Occupational Segregation by Gender 1970-2009: Adjusting for the Impact of Changes in the Occupational Coding System. Demography, 50(2), 471–494.

Boddington, P. (2017). Towards a code of ethics for artificial intelligence. Springer International Publishing. Retrieved from: www.springer.com/gp/book/9783319606477

Bradley, S. R., Gicheva, D., Hassell, L., & Link, A. N. (2013). Gender differences in access to private investment funding to support the development of new technologies (UNCG Economics Working Papers No. 13–9). University of North Carolina at Greensboro, Department of Economics. Retrieved from: https://ideas.repec.org/p/ris/uncgec/2013_009.html

Brown, J. (2016, March 22). Women as full-time business school faculty – Does world region make a difference? Retrieved from: http://aacsbblogs.typepad.com/dataandresearch/2016/03/women-as-full-time-business-school-faculty-does-world-region-make-a-difference.html

Brush, C. G., Greene, P. G., Balachandra, L., & Davis, A. (2014). Diana Report: Women entrepreneurs 2014: Bridging the gender gap in venture capital. Retrieved from: http://www.babson.edu/Academics/centers/blank-center/global-research/diana/Documents/diana-project-executive-summary-2014.pdf

Chanavat, A., & Ramsden, K. (2013). Mining the metrics of board diversity. Retrieved from: https://www.thomsonreuters.com/en/press-releases/2013/average-stock-price-of-gender-diverse-corporate-boards-outperform-those-with-no-women.html

CompTIA. (2017). 2017 IT Industry job market & salary trends analysis. Cyberstates. Retrieved from: http://www.cyberstates.org/

CompTIA. (2018). 2018 IT (Information Technology) industry trends analysis. Retrieved from: https://www.comptia.org/resources/it-industry-trends-analysis

Crawford, K. (2018). Artificial Intelligence's white guy problem. The New York Times, January 20. Retrieved from: https://www.nytimes.com/2016/06/26/opinion/sunday/artificial-intelligences-white-guy-problem.html

Cummings, L. M. (2015). Gender Equality in science, technology, engineering, agricultural sciences and mathematics (STEAM) academic pipeline: Challenges transferring knowledge to practice. Retrieved from: https://www.usaid.gov/sites/default/files/USAID-Report-Sep-30-2015-Final.pdf

Data 2x. (2017). Ready to Measure: Phase II. Indicators available to monitor SDG gender targets, p. 21. Retrieved from: http://www.data2x.org/what-is-gender-data/ready-to-measure/

David, P. A., & Shapiro, J. S. (2008). Community-based production of open-source software: What do we know about the developers who participate? Information Economics and Policy, 20(4), 364–398. Retrieved from: https://doi.org/10.1016/j.infoecopol.2008.10.001

Dawson, J., Kersley, R., & Natella, S. (2014). The CS Gender 3000: Women in senior management. Credit Suisse. Retrieved from: https://publications.credit-suisse.com/tasks/render/file/index.cfm?fileid=-8128F3C0-99BC-22E6-838E2A5B1E4366DF

Deloitte. (2017). Women n the boardroom: A global perspective (5th edition). Retrieved from: https://www2.deloitte.com/za/en/pages/deloitte-africa/articles/women-in-the-boardroom.html

Deloitte, & Alliance for Board Diversity. (2016). Missing pieces report: The 2016 board diversity census of women and minorities on Fortune 500 Boards. Retrieved from: http://theabd.org/2016%20Board%20Diversity%20Census_Deloitte_ABD_Final.PDF

Donnelly, G. (2017). Only 3% of Fortune 500 companies share full diversity data. Fortune, June 7. Retrieved January 27, 2018, from: http://fortune.com/2017/06/07/fortune-500-diversity/

Ernst & Young. (2015). Venture capital insights – 4Q14: Global VC investment landscape. Ernst & Young. Retrieved from: http://www.ey.com/Publication/vwLUAssets/Venture_Capital_Insights_4Q14_-_January_2015/$FILE/ey-venture-capital-insights-4Q14.pdf

European Commission. (2015). She figures 2015: Gender in research and innovation, 2.

Evans Data Corporation. (2017). Global Developer Population and Demographic Study 2017 (1).

Evans, W., & Rangarajan, S. (2017,). Hidden figures: How Silicon Valley keeps diversity data secret. Reveal News, October 19. Retrieved from: https://www.revealnews.org/article/hidden-figures-how-silicon-valley-keeps-diversity-data-secret/

Ford, D., Smith, J., Guo, P. J., & Parnin, C. (2016). Paradise unplugged: Identifying barriers for female participation on stack overflow. Proceedings of the 2016 24th

ACM SIGSOFT International Symposium on Foundations of Software Engineering - FSE 2016, 846–857. Retrieved from: https://doi.org/10.1145/2950290.2950331

Frehill, L., Abreu, A., & Zippel, K. (2015). Gender, science, and occupational sex segregation. In W. Pearson, L. Frehill, & C. McNeely (Eds.), Advancing women in science: An international perspective (pp. 51–92). Switzerland: Springer. Retrieved from: http://www.springer.com/br/book/9783319086286

Frost & Sullivan. (2017). The 2017 Global Information Security Workforce Study: Women in cybersecurity. Retrieved from: https://iamcybersafe.org/wp-content/uploads/2017/03/WomensReport.pdf

GitHub. (2018). "User search". Retrieved 2018-07-12 (showing 29,707,507 available users).

GlassDoor (2018). Best jobs in America. Retrieved 2018-06-25 from: https://www.glassdoor.com/List/Best-Jobs-in-America-LST_KQ0,20.htm

Gompers, P. A., & Wang, S. Q. (2017a). And the children shall lead: Gender diversity and performance in venture capital (Working Paper No. 23454). National Bureau of Economic Research. Retrieved from: https://doi.org/10.3386/w23454

Gompers, P. A., & Wang, S. Q. (2017b). Diversity in innovation (Working Paper No. 23082). National Bureau of Economic Research. Retrieved from: https://doi.org/10.3386/w23082

Gumpertz, M., Durodoye, R., Griffith, E., & Wilson, A. (2017). Retention and promotion of women and underrepresented minority faculty in science and engineering at four large land grant institutions. PLOS ONE, 12(11), e0187285. Retrieved from: https://doi.org/10.1371/journal.pone.0187285

HackerRank. (2018). 2018 Women in tech report. Retrieved May 29, 2018, from: https://research.hackerrank.com/women-in-tech/2018/

HackerRank (2018). HackerRank developer survey 2018. Retrieved June 6, 2018, from: https://www.kaggle.com/hackerrank/developer-survey-2018/home

Heeks, R. (2005). Developing women's ICT-based enterprise: Summary of an international knowledge-sharing workshop (Workshop report). Retrieved from: https://assets.publishing.service.gov.uk/media/57a08c5ced915d622c0012c5/R8352-WorkshopKeralaReport.pdf

Hewlett, S. A., & Sherbin, L. (2014). Athena Factor 2.0: Accelerating female talent in science, engineering & technology. Retrieved from: http://www.talentinnovation.org/_private/assets/Athena-2-ExecSummFINAL-CTI.pdf

Hunt, J. (2010). Why do women leave science and engineering? (Working Paper No. 15853). National Bureau of Economic Research. Retrieved from: https://doi.org/10.3386/w15853

Hunt, V., Layton, D., & Prince, S. (2015). Diversity matters. Retrieved from: https://www.mckinsey.com/~/media/mckinsey/business%20functions/organization/our%20insights/why%20diversity%20matters/diversity%20matters.ashx

Hunt, V., Yee, L., Prince, S., & Dixon-Fyle, S. (2018). Delivering growth through diversity in the workplace. McKinsey & Company. Retrieved from: https://www.mckinsey.com/business-functions/organization/our-insights/delivering-through-diversity

ILO. (2017a). Economic impacts of reducing the gender gap. Research brief. Retrieved from: http://www.ilo.org/global/research/publications/what-works/WCMS_577685/lang--en/index.htm

ILO. (2017b). World Employment and Social Outlook: Trends for women 2017. Retrieved January 20, 2018, from: http://www.ilo.org/global/research/global-reports/weso/trends-for-women2017/lang--en/index.htm

ILO. (2018). Women and men in the informal economy: A statistical picture (3rd edition). Retrieved from: http://www.ilo.org/global/publications/books/

WCMS_626831/lang--en/index.htm
IMF. (2018). Financial Access Survey (FAS): Gender pilot outcomes.

Information is Beautiful. (2018). Diversity in Tech: Information is Beautiful. Infographics. Retrieved January 28, 2018, from: https://informationisbeautiful.net/visualizations/diversity-in-tech/

Institutional Shareholder Services, Inc, & Regulation, F. (2017, January 5). Gender parity on boards around the world. Retrieved March 5, 2018, from: https://corpgov.law.harvard.edu/2017/01/05/gender-parity-on-boards-around-the-world/

Kelley, D., Baumer, B. S., Brush, C. G., Greene, P. G., Mahnaz, M., Mahdi, M., … Dean, M. (2017). Global Entrepreneurship Monitor: Women's entrepreneurship 2016/2017 report. Retrieved from: https://www.babson.edu/Academics/centers/blank-center/global-research/gem/Documents/GEM%202016-2017%20Womens%20Report.pdf

Kuschell, K., & Lepeley, M.-T. (2016). Women start-ups in technology: Literature review and research agenda to improve participation. International Journal of Entrepreneurship and Small Business, 27(2/3), 333–346.

Lakhani, K. R., & Von Hippel, E. (2003). How open source software works: "Free" user-to-user assistance. Research Policy, 32(6), 923–943. Retrieved from: https://doi.org/10.1016/S0048-7333(02)00095-1

MacDougall, A., Valley, J., Adler, J., Bettel, C., Param, A., Schmidt, J., … Suppa, O. (2017). 2017 Diversity disclosure practices report: Women in leadership roles at TSX-listed companies. Retrieved from: http://www.osler.com/en/resources/governance/2017/2017-diversity-disclosure-practices-report-women

Molina, M., Lin, S., & Wood, C. (2015). Connected Women 2015: Accelerating the digital economy: Gender diversity in the telecommunications sector. A.T. Kearney & GSMA. Retrieved from: http://www.atkearney.tw/communications-media-technology/ideas-insights/connected-women-2015

NVCA. (2016, January 15). $58.8 Billion in venture capital invested across U.S. in 2015, according to the MoneyTree Report. Retrieved from: https://nvca.org/pressreleases/58-8-billion-in-venture-capital-invested-across-u-s-in-2015-according-to-the-moneytree-report-2/

OECD. (2017). OECD Digital Economy Outlook 2017. Paris: OECD Publishing. Retrieved from: https://www.oecd-ilibrary.org/science-and-technology/oecd-digital-economy-outlook-2017_9789264276284-en

OECD STI. (2018). Empowering women in the digital age. OECD Directorate for Science, Technology and Innovation. Retrieved from: https://www.oecd.org/social/empowering-women-in-the-digital-age-brochure.pdf

Parsheera, S. (2018). A gendered perspective on Artificial Intelligence. In ITU (Ed.), Machine learning for a 5G future (125–131). Santa Fe, Argentina: International Telecommunication Union. Retrieved from: https://www.itu.int/dms_pub/itu-t/opb/proc/T-PROC-KALEI-2018-PDF-E.pdf

Quirós, C. T., Morales, E. G., Pastor, R. R., Carmona, A. F., Ibáñez, M. S., & Herrera, U. M. (2018). Women in the digital age. European Commission. Retrieved from: https://ec.europa.eu/digital-single-market/en/news/increase-gender-gap-digital-sector-study-women-digital-age

Richard, G. T., Kafai, Y. B., Adleberg, B., & Telhan, O. (2015). StitchFest: Diversifying a college hackathon to broaden participation and perceptions in computing. SIGCSE '15: Proceedings of the 46th ACM Technical Symposium on Computer Science Education (March), 114–119. Retrieved from: https://doi.org/10.1145/2676723.2677310

Sassler, S., Michelmore, K., & Smith, K. (2017). A tale of two majors: Explaining the gender gap in STEM employment among computer science and engineering degree holders. Social Sciences, 6(3), 69. Retrieved from: https://doi.org/10.3390/socsci6030069

Servon, L. J., & Visser, M. A. (n.d.). Progress hindered: The retention and advancement of women in science, engineering and technology careers. Human Resource Management Journal, 21(3), 272–284. Retrieved from: https://doi.org/10.1111/j.1748-8583.2010.00152.x

Shauman, K. A. (2017). Gender differences in the early employment outcomes of STEM doctorates. Social Sciences, 6(1), 24. Retrieved from: https://doi.org/10.3390/socsci6010024

Stack Overflow. (2018). Stack Overflow Developer Survey 2018. Retrieved April 4, 2018, from: https://stackoverflow.com/insights/survey/2018/?utm_source=so-owned&utm_medium=social&utm_campaign=-dev-survey-2018&utm_content=social-share

Stack Overflow. (2018). "Users" Retrieved July 12, 2018 (showing 8,731,692 available users).

Tapia, A. H., & Kvasny, L. (2004). Recruitment is never enough: Retention of women and minorities in the IT workplace. In Proceedings of the 2004 SIGMIS Conference on Computer Personnel Research: Careers, Culture, and Ethics in a Networked Environment (84–91). New York, NY: ACM. Retrieved from: https://doi.org/10.1145/982372.982392

The World Academy of Sciences. (2018). TWAS Fellows. Retrieved June 5, 2018, from: https://twas.org/directory/overview

Thomas, A., Dougherty, J., Strand, S., Nayar, A., & Janani, M. (2016). Decoding diversity: The financial and economic returns to diversity in tech. Retrieved from: https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2016/07/Diversity_report_7.7.16_web-1.pdf

UNCTAD. (2014). Empowering women entrepreneurs through information and communications technologies: A practical guide (UNCTAD Current Studies on Science Technology and Innovation, No. 9). Retrieved from: https://unctad.org/en/PublicationsLibrary/dtlstict2013d2_en.pdf

UNCTAD. (2015). Global assessment of sex-disaggregated ICT employment statistics: Data availability and challenges on measurement and compilation, 54.

UNESCO Institute for Statistics. (2017). Women in science (Fact Sheet No. 43; FS/2017/SCI/43). Retrieved from: http://uis.unesco.org/sites/default/files/documents/fs43-women-in-science-2017-en.pdf

U.S. Equal Employment Opportunity Commission. (2016). Diversity in high tech. Retrieved from: https://www.eeoc.gov/eeoc/statistics/reports/hightech/index.cfm#_ftnref16

US Government Accountability Office. (2017). Diversity in the technology sector. Retrieved from: https://www.gao.gov/assets/690/688460.pdf

Vasilescu, B. (2014). Human aspects, gamification, and social media in collaborative software engineering. Companion Proceedings of the 36th International Conference on Software Engineering. ICSE Companion 2014, 646–649. Retrieved from: https://doi.org/10.1145/2591062.2591091

Vasilescu, B., Filkov, V., & Serebrenik, A. (2015). Perceptions of diversity on GitHub: A user survey. Proceedings of the Eighth International Workshop on Cooperative and Human Aspects of Software Engineering, 50–56. Retrieved from: https://doi.org/10.1109/CHASE.2015.14

Vasilescu, B., Posnett, D., Ray, B., van den Brand, M. G. J., Serebrenik, A., Devanbu, P., & Filkov, V. (2015). Gender and tenure diversity in GitHub teams. In Crossings. Seoul, Korea. Retrieved from: http://delivery.acm.org.offcampus.lib.washington.edu/10.1145/2710000/2702549/p3789-vasilescu.pdf?ip=128.95.104.66&id=2702549&acc=ACTIVE%20SERVICE&key=B63ACEF81C6334F5%2EF43F328D6C8418D0%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&__acm__=1518685543_74e499233266245940ed485ccf165e04

Wang, Z., Wang, Y., & Redmiles, D. (2018, May). Competence-confidence Gap: A threat to female developers' contribution on GitHub. In: ICSE-SEIS'18, Proceedings of 40th International Conference on Software Engineering: Software Track (p. 10).

Weissman, C. G. (2016, August 18). The women changing the face of AI. Retrieved July 12, 2018, from: https://www.fastcompany.com/3062932/ai-is-a-male-dominated-field-but-an-important-group-of-women-is-changing-th

WIT Leadership Round Table Metrics Working Group. (2016). Diversity metrics for technology companies.

World Economic Forum. (2017). The global gender gap report 2017. Retrieved from: https://www.weforum.org/reports/the-global-gender-gap-report-2017/

Yoder, B. (2016). Engineering by the numbers. American Society for Engineering Education. Retrieved from: https://www.asee.org/documents/papers-and-publications/publications/college-profiles/16Profile-Front-Section.pdf

Zlotnick, F., Smith, A., Linksvayer, M., & Filippova, A. (2018). The open source survey. Retrieved from: URL https://github. com/github/open-source-survey