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FAIR PROJECTS – BAD DATA?

EVALUATING THE GENDER BALANCE IN SCIENCE PROJECTS

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ABSTRACT

Researchers are more and more frequently required to report the gender balance of their teams in order to receive funding for their research projects. In Europe for instance, Horizon 2020 guidelines determine that applications with a balanced, 50/50 representation of women and men will be given preference, and each project must at least justify the composition of their teams and leadership positions.

In scientific fields where women are still a minority, like robotics or artificial intelligence, or many STEMM fields in general, this approach has left the applicants with the issue of how to justify the ratio of women on their teams. For individual projects and project leaders, realistic objectives are required that take into account specific framework conditions in different scientific fields.

This paper examines approaches to measure the disciplinary background and career development of women and men in science by assessing a range of available data sources. It provides insights on how to derive figures allowing science projects to evaluate their gender ratios against a possible underrepresen-tation of women.

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1.INTRODUCTION

Despite many efforts and gradual increases, women's share in many academic STEMM (Science, Technology, Engineering, Mathematics und Medicine) fields is low, although with wide variations at regional and national levels as well as for scientific disciplines and career levels. In the EU, 48% of all doctoral graduates were women in 2016: They were over-represented for instance in education (68%), but clearly underrepresented in information and communication technologies (21%) or engineering, manufacturing and construction (29%). At the level of professors (grade A staff), women's shares within the EU are particularly low for engineering and technology (12%) or natural sciences (18%), and highest for the humanities (32%). (All figures from European Commission 2019 - SHE FIGURES 2018).

The reasons for the disproportionately low participation of women in many fields are manifold and have been discussed extensively (see e.g. The Lancet 2019; PLOTINA 2015; Ranga, Gupta & Etzkowitz 2012; National Academy of Sciences et al. 2007): They include societal causes (such as role models, typical male and female fields, negative stereotypes) and early career choices taken in school – which influence the available women's talent pool at the very beginning of academic education. But even when women decide to pursue their studies in STEMM fields, there is a high probability that they are thrown off their career path by a phenomenon labelled **"leaky pipeline".** This can be observed in all fields of science (and in industry as well as in all other societal domains): Along career and hierarchical levels, the representation of women declines continuously with each step up. This is also true for fields where women's shares of bachelor / master students and doctorates have been large for years and thus there would be enough qualified women available for high-level positions (see National Academy of Sciences et al. 2007). The leaky pipeline can be considered a result of the interplay of many hindering factors, such as institutional climate at universities and research organisations and unfavourable working conditions (i.e., short-term contracts, long working hours, lack of family friendliness and work-life-balance). Also, cultural and structural, frequently unconscious biases play a decisive part in this context (e.g., homo-sociality in networks, "all-boys team-networking", male dominance of evaluation and peer-review processes). Unconscious biases influence our perceptions and decisions, based on previous experiences, associations and preferences already made in the past (see e.g. Staats et al. 2017 for an overview). Despite striving for objectivity, we assess a person not only by performance, but also by affiliation to a specific group that we (unconsciously) consider as positive or negative. Also, it can be a question of visibility, for instance when setting up a research or project team. The principal investigators and proposal writers refer to people they already know, who are part of their network, who have contributed substantially in the past and have been able to attract attention.

At the organizational level, many universities and research organizations act to increase the number of women, to remove discriminating barriers in science and decision-making, to overcome unconscious biases and to counteract the leaky pipeline. These actions include for instance advertising certain fields of science in schools or even kindergarten or offering summer schools to explore what it might be like to study. In terms of keeping qualified women in science and research, gender equality plans are developed and implemented (as for instance supported by the ongoing PLOTINA project – see PLOTINA 2015).

With regards to research funding, European and national funding agencies increasingly require **projects to report on their gender balance** and make this a criterion in their funding decisions. This is an attempt to urge leading scientists to improve the gender balance of their teams. For instance, projects funded by the EU's Research and Innovation programme Horizon 2020 should pay attention to gender equality in terms of human resources (balanced participation of women and men in the research teams), as well as in research contents (European Union 2019). In particular, the criteria for human resources is explained as follows:

> *"When applying for a grant under Horizon 2020, you are encouraged to promote gender balance at all levels in your teams and in management structures. Applicants should seek at having a balanced participation, as close as possible to 50/50, of both men and women in the teams and among the leading roles. At the evaluation stage, gender balance in staff is one of the ranking factors that come into play to prioritise the proposals above the threshold with same scores. When it is used, evaluators need to compare the shares of men and women in the personnel named in the proposals (in Part B, section 4.1, of the proposal template) and they will rank higher the proposal with the share closer to 50/50." (European Union 2019).*

Besides being a value in its own right, gender equality makes sense in terms of innovation, better results or positive working atmosphere (see e.g. Schiebinger et al. 2011-2018; Bert 2018). And many measures and initiatives are already in place that support this development (see above).

But in the short term, given the current situation as described above, demanding a balanced participation of 50:50 in projects is highly unrealistic for a range of scientific fields, in particular from the STEMM domain. Still, the pressure is there, and project leaders are constantly asked to raise the number of women, regardless of the fields of science involved or the aim of the project. Researchers and project applicants confronted with respective criteria might be unsettled by such demands and question whether they actually have the responsibility to act within their project and the possibility to do so given the framework conditions in their specific scientific fields (see as well Grasenick 2019). Thus, for individual projects and project leaders, realistic goals are required. In order to get an idea of which target values could be realistic and at the same time challenging, knowledge of the actual proportion of women in research is a necessary prerequisite for a target-oriented discussion.

In this context, this paper addresses the following questions: How should a research team determine its gender balance goals? What is a good and fair gender balance at different career levels (PhD students, work package leaders etc.) and for different scientific disciplines? How can it be measured? What are good reference numbers? These questions are not only of relevance for research teams, projects or project consortia who apply for funding, but also for the funding agencies, programme managers and evaluators of funding programmes, as well as for universities and research organisations (e.g. in the context of performance agreements and the goals that are determined by them).

The aim of this paper is to make a contribution to an evidence-based discussion in this field. We have analysed international data sources that cover gender-specific data in research and assessed the usefulness of these sources. After providing an overview of these sources and potentially suitable indicators, we apply them to a case study from the field of Computer Sciences. We conclude with our suggestions of how to proceed when assessing and setting goals for a team's gender balance.

2. BENCHMARKING GENDER-BALANCE IN R&D-PROJECTS – A DATA-BASED APPROACH

In the last decades, a series of attempts have been undertaken to establish gender-related data sources in science. At the institutional level, many universities and research organisations have implemented gender-monitoring systems. There are also a range of data compilations that cover and compare many countries and/or organizations.

Before discussing the different data sources in more detail, it must be clarified which criteria a database should fulfil to be relevant for the purpose of a gender-balance benchmark.

CRITERIA FOR THE RELEVANCE OF DATA SOURCES

- **Regular update of data:** Several publications which offer highly relevant insights on the gender balance in sciences and related professional fields are not available on a regular basis. This includes for instance the Elsevier report on gender in the global research landscape 2017 (see below). Some of these reports set a specific disciplinary focus, for instance, the World Economic Forum's "Global Gender Gap Report" 2018 focusses particularly on Artificial Intelligence[1]. However, one-time reports or studies are reduced in their value, since the reference values will not be updated on a regular basis. An essential criterion for the data sources we assess here is that they are updated regularly.

In addition to this formal criterion, several content criteria are of relevance. Databases in question should give information about those framework factors which have an impact on the number of women re-

1 See World Economic Forum (2018). Another example is the "Global Survey of Physicists" conducted in 2009/2010 by the Union of Pure and Applied Physics (IUPAP). Currently, the same organisation conducts a global survey and study of publication patterns of Mathematical, Computing and Natural Scientists, see Butcher et al. (2019).

presented in research (see e.g. Ranga, Gupta & Etzkowitz 2012). Some of the relevant dimensions are:

- **Field of research:** Women's participation varies substantially between different research fields. In general, in Humanities and Social Sciences their participation is higher than in most Engineering or Natural Sciences.
- **Countries:** Women's participation is also a question of a country's "research culture". Even within the same field of research, one can find very different participation rates depending on the country.
- **Leaky pipeline:** The so called "leaky pipeline" is a well-known pattern across all sciences and can be summarized as follows: The higher the career-level the lower the representation of women.

So, when searching and selecting a database, it must be clarified which of these parameters are covered by the provided indicators. To anticipate our findings: None of the reports and databases analysed covers all relevant dimension at once. There are well elaborated databases that are certainly useful for specific purposes, but each one of them has restrictions. Some of them are limited to certain countries[2] or regions[3]. Others only cover certain research fields[4] or will not be updated.

In this chapter we provide an overview of databases and selected indicators that we consider useful to assess whether the gender composition of the research team is well balanced within the (international) research framework. To test if the suggested indicators are feasible, we elaborate a case study in the research field of computer sciences. The findings are summarized in a concluding chapter.

2.1 RELEVANT DATA SOURCES

Since our focus is on international research groups, we have limited the search to those databases that provide data on an international level. A screening of international data sources shows that there are at least four approaches which can help research consortia in assessing their gender balance. Three of them provide country-specific data, one is collecting comparable (publication) data on the level of universities ("Leiden ranking").

CROSS-COUNTRY DATABASE

European Commission (2019). "She Figures 2018": Probably the most useful source in this context are the "She Figures", which are updated every three years by the European Commission. The last release of "She Figures 2018" was published in February 2019 (European Commission 2019). The report provides data for a wide range of gender-specific indicators in the field of R&D, universities and innovation. All data are presented by sex and at the individual country level as well as the broader EU level for the current 28 EU Member States and the associated countries. Many indicators are published for six main Fields Of R&D ("FORD") according to the OECD Frascati Manual[5]. Other indicators like "doctoral graduates" are based on the ISCED-F 2013 classification (UNESCO Institute of Statistics, 2014) which distinguishes 29 narrow fields of education and training ("fields of studies -FoS") organised in 10 broad groups[6]. One limitation of this source is that most countries from outside of the EU are not taken into account.

Elsevier (2017). "Gender in the Global Research Landscape. Analysis of research performance through a gender lens across 20 years, 12 geographies, and 27 subject areas": Unlike "She Figures" this report covers worldwide data and shows development over 20 years. However, there is no clear evidence for a regular update of the report. The study is based on publications from Scopus and ScienceDirect and a combination of Author Profiles with gender-name data from different platforms. The report, published in 2017, includes shares and absolute numbers of men and women as researchers by 27 different subject areas[7]. These subject areas are based on the classification which is used by the Scopus database and differs from classifications likes FoS or FORD mentioned above. Data are provided for 12 comparator countries: the EU-28 as a group, as well as four selected individual EU member states (United Kingdom, France, Denmark, Portugal) and seven countries from other continents (United States, Canada, Australia, Brazil, Japan, Mexico, Chile).

UNESCO data-base and UNESCO Science Report (2015): The UNESCO Science Report is published every five years and maps STI (Science, Technology & Innovation) data around the world and relies on data provided by the UNESCO database (UNESCO Institute for Statistics 2019). One chapter in the current report (2015) deals with the gender gap in science and engineering and provides general gender related data on an international level (country/world-regions). Some of the indicators are presented by broad science fields ("FORD"). Apart from the report

2 For instance, the "Science in Australia Gender Equity" (SAGE) initiative (SAGE 2019).

3 A well elaborated example is the gender report of the universities of Nordrhein-Westfalen (Germany) that is published every three years. This report, and a well-presented online portal provide detailed gender related data (Netzwerk Frauen- und Geschlechterforschung NRW 2019).

4 For instance, for biomedical research fields there is a very detailed data collection based on worldwide publications (see Holman, Stuart-Fox & Hauser 2018).

5 According to the OECD Frascati Manual (OECD 2015) these fields are (1) Natural sciences (2) Engineering and technology, (3) Medical sciences, (4) Agricultural sciences, (5) Social sciences and (6) Humanities. The breakdown of researchers by field of R&D is based on the field where they work and not according to the field of their qualification (see also European Commission 2019 - She Figures 2018, p. 188).

6 According to the ISCED-F 2013 classification, these 10 broad groups are: (1) education; (2) humanities and arts; (3) social sciences, journalism and information; (4) business administration and law; (5) natural sciences, mathematics and statistics; (6) information and communication technology; (7) engineering, manufacturing and construction; (8) agriculture, forestry, fisheries and veterinary; (9) health and welfare; and (10) services.

7 Scopus is published by Elsevier. The classification distinguishes between 27 areas, which are: Multidisciplinary (journals like Nature and Science), Agricultural & Biological Sciences, Arts & Humanities, Biochemistry/Genetics/Molecular Biology, Business, Management, & Accounting, Chemical Engineering, Chemistry, Computer Science, Decision Sciences, Dentistry, Earth & Planetary Sciences, Economics/Econometrics/Finance, Energy, Engineering, Environmental Science, Health Professions, Immunology & Microbiology, Materials Science, Mathematics, Medicine, Neuroscience, Nursing, Pharmacology, Toxicology, & Pharmaceutics, Physics & Astronomy, Psychology, Social Sciences, Veterinary

UNESCO is also running an open source database where gender related data on science, technology and innovation (STI) by country and broad fields of sciences are monitored (UNESCO Institute for Statistics 2019, data.uis.unesco.org/). In general, the database covers 163 countries worldwide (including all 12 countries that are used as comparators by Elsevier, for instance, and all EU member states). But country data are incomplete or even fragmentary for important indicators.

CROSS-ORGANISATIONAL DATA BASE

Leiden Ranking (2019): The current CWTS Leiden Ranking 2019 includes information of scientific performance of nearly 1000 major universities from 56 different countries. This covers for instance universities from most EU member states[8] and from all 12 comparator countries that were used in the Elsevier Report (2017). The CWTS Leiden Ranking benchmarks universities according to their publication performance. The CWTS Leiden Ranking 2019 is based on bibliographic data from the Web of Science database and presents a variety of indicators to explore the performance of universities from different angles. Since 2019 it also includes gender indicators based on publications. Data are provided on the level of universities, which by themselves are mapped by countries. The data are presented along five scientific fields (Biomedical and health sciences, Life and earth sciences, Mathematics and computer science, Physical sciences and engineering, Social sciences and humanities). This classification is more restricted compared to the data of She Figures, since data of narrow scientific fields are not available.

OVERVIEW OF DATABASES

Table 1 gives an overview which relevant dimension are covered by each database:

- All databases do cover different research fields to a certain extent. Some provide data for detailed fields of research and development ("FORD") or fields of study ("FoS"), others are limited to broad classifications.
- Concerning the coverage of countries, all database provide data on the level of countries. However, in the Elsevier and UNESCO databases, countries that are important from a European perspective are missing. The Leiden ranking is by concept comparing research organisations and not countries. But as the organisations are also linked to countries one can indirectly derive country specific information.
- Only She Figures includes different career stage (like doctoral graduates or professors).

	Database covering different…			
database	**fields of research**	**countries**	**research organisations**	**career stages**
UNESCO Science Report	yes	(yes)	no	no
Elsevier – Gender report	yes	(yes)	no	no
She Figures	yes	yes	no	yes
Leiden ranking	yes	(no)	yes	no

Table 1: Relevant databases and the dimensions they cover
source: own compilation

INTRA-ORGANISATIONAL DATABASES

In the databases discussed above, we find three cross-country approaches and one cross-organisational database ("Leiden ranking"). They provide orientation on the international situation concerning specific gender-related indicators. These data can serve as a benchmark for checking the gender balance of specific research consortia against the international context.

A similar benchmark could also be derived directly in a more bottom-up approach, with data from the partner-organisations of research consortia themselves: Today many universities and research institutions provide annual gender monitoring reports, which give an up-to-date overview of women's participation in the area of teaching and research. Most of these monitoring reports also include women's participation by career stage and science field (which normally has the structure of a "leaky-pipeline"). Even if a university does not publish such reports, internal monitoring systems are usually in place including the respective information. For example, the University of Manchester (UOM) publishes an Equality Information Report[9] with information on all staff and students differentiated by diversity dimensions. It includes statistics of the proportion of women for the university overall (all sciences aggregated). However, this has to be based on more detailed information regarding departments and science fields. For instance, the Department of Computer Science, reports that *"women make up 24% of academic staff, higher than UK average"* (University of Manchester – Department of Computer Science 2019). Similarly, the Technical University Munich (TUM) offers a diversity reader, which includes an overview on women at different career levels (Technische Universität München 2018).

2.2 SELECTED INDICATORS

Most of the databases we discussed above include a series of gender-related indicators, which cover a wide range of topics. The screening of these indicators reveals that for the purpose of extracting reference values, only a few of them are of relevance. These will be presented in the following:

8 The ranking 2019 includes no universities from the following five EU member states: Bulgaria, Cyprus, Latvia, Luxembourg, Malta.
9 For the 2019 report see University of Manchester (2019). E.g. women make up 49.8% of the workforce overall and 42.2% of academic staff, but no information on the level of departments or scientific disciplines is given.

PROPORTION OF WOMEN RESEARCHERS IN GENERAL AND FOR SPECIFIC RESEARCH FIELDS

"Share of female researchers by country, 2013 or closest year (%)", (Source: UNESCO Science Report, p. 87f.): Values are given for countries and regions all over the world for all fields of sciences. For (world-)regions like EU, Latin America or West Asia single values are published. Unfortunately for most individual countries, only ranges of values are published. For instance, according to the report, in Austria women's share of researchers is between 25% and 34,9%. A further restriction is that the indicator does not differentiate between different levels of career stages.

"Female researchers by field of science, 2013 or closest year (%)" (Source: UNESCO Science Report, p. 87): This indicator goes one step further than the former indicator. It covers more than 75 countries from all over the world and differentiates broad research fields (Natural sciences, Engineering and technology, Medical sciences, Agricultural sciences and Social sciences and humanities). Although values are available for more than 75 countries, for many important countries in science there are no data (e.g. USA, Germany, UK, Italy, France, Austria) provided. Furthermore, the indicator also does not differentiate between different levels of career stages.

"Proportion and number of researchers by gender […] and research areas, 2011 – 2015", (Source: Elsevier): This indicator is provided in two variations. The first gives an overall picture of women researchers (p.18), the second indicator (p. 24) differentiates between 27 research areas (e.g. Medicine, Engineering, Neuroscience) according to the Scopus classification of fields of study (ASJC). The indicators cover selected countries outside the EU (e.g. US, CAN, BR, AUS) as well as the EU-28 and selected individual EU member-states (UK, FR, P, DK). However, important research-intense countries like GER[10], IT, AT, CH etc. are not included. Therefore, there are certain restrictions concerning the regional coverage of the data. Another disadvantage is that the indicator does not differentiate between career levels.

CAREER LEVEL

Doctoral graduates: "Proportion (%) of women among doctoral graduates", 2016. (Source: She Figures 2018): The indicator is provided for all researchers (p. 20), as well as by broad fields of study[11] (p.23). Furthermore, for selected STEM-fields like natural sciences/mathematics and statistics, ICT and engineering/manufacturing and construction (p.26) data are also available by narrow fields of study[12]. Data are presented by country and EU-28. Usually, doctoral graduates are a very important group in academic research teams, as they frequently are responsible for the (time-consuming) field research (laboratory research etc.). Therefore, this indicator can serve as a meaningful benchmark for research groups applying for projects.

Full professorship: proportion (%) of women among Grade A positions (Source: She Figures 2018): For the level of leadership the "She Figures 2018" provides data for full professors by gender. In the terminology of the report, this group is labelled as Grade A[13]: In this context, two indicators are published: The indicator "Evolution of the proportion (%) of women among Grade A positions, 2013 vs. 2016", (p. 119) provides data for all sciences (aggregated) and a second indicator provides data by six broad fields of R&D ("The proportion (%) of woman among grade A staff among by main field of R&D[14], p. 121).

PUBLICATIONS:

Proportion of women researchers in publications. (Source: Leiden Ranking 2019) (*"The number of female authorships as a proportion of a university's number of male and female authorships"*)[15]: Data are available on the level of universities. However, the Leiden ranking does not differentiate between first and co-authors or the scientific impact of the publications. The proportion of women's authorships from this ranking could be used as a rough reference (though not a direct benchmark of publications) for the gender balance of a specific research team or project consortium.

10 However, there is a separate report for Germany that was published before the Global Report (Elsevier 2015).

11 The ISCED-F 2013 classification (UNESCO Institute of Statistics, 2014) distinguishes 29 narrow fields of education and training organised in 10 broad groups: education; humanities and arts; social sciences, journalism and information; business administration and law; natural sciences, mathematics and statistics; information and communication technology; engineering, manufacturing and construction; agriculture, forestry, fisheries and veterinary; health and welfare; and services.

12 Selected narrow fields of study: Natural sciences, mathematics and statistics (Biological and related sciences; Environment; Physical sciences; Mathematics and statistics); Information and Communication Technologies; Engineering, manufacturing and construction (Engineering and engineering trades; Manufacturing and processing; Architecture and construction)

13 "Grade A either corresponds to the rank of full professor, or to the highest post at which research is normally conducted." (SHE Figures 2018, p. 118 and p 190)

14 Fields of R&D: NS = natural sciences; ET = engineering and technology; MS = medical sciences; AS= agricultural sciences; SS = social sciences; H = humanities.

15 This indicator is abbreviated as PA(F|MF) in the Leiden Ranking.

Table 2 summarises the discussed indicators.

	Source	Fields of research/study			Country level
		All fields (aggregated)	broad fields	narrow field	
Proportion of women Researchers (general)					
"Share of female researchers, 2013 (%) or closest year (%)"	UNESCO Science report, p. 88ff. (UNESCO open source data)	yes	No	no	yes (but important developed countries missing, for many countries only value ranges available)
"Female researchers by field of science, 2013 or closest year (%)"	UNESCO Science report, p. 87ff. (UNESCO open source data)	no	Yes (FORD*)	no	yes (but important developed countries missing)
Proportion of researchers by gender (2011-2015) and subject area	Elsevier, p. 24	yes	No	Yes (ASJC**)	yes (but only selected EU- and non-EU- states, EU28 included)
Career Level					
Doctoral graduates: Proportion (%) of women among doctoral graduates, 2016	She Figures, p. 19f., p. 23, p. 26	yes	Yes (FoS**)	Yes, but only for STEM- fields (FoS**)	yes
Grade A: proportion (%) of women among Grade A positions, 2016	She Figures, p. 119, p121	yes	Yes	no	Yes (some countries missing)
Publication					
"The number of female authorships as a proportion of a university's number of male and female authorships (2014-2017)"	Leiden Ranking	no	Yes	no	(no) (but indirect by location of universities)

Table 2 Useful gender-related indicators from international data bases / reports
Source: own compilation, *FORD: Field of R&D, **FoS: field of study, ***ASJC: All Science Journal Classification Codes (Scopus)

UNIVERSITY BASED INDICATORS FOR TEAMS AND CONSORTIA

Benchmarking the gender balance of a research team against the data from the above databases is one possible way of estimating the gender balance of a team within the international research landscape. The international perspective is highly relevant, since at least for post-doc positions onward, it is the global scientific community that's relevant and teams at one university or institute are often composed internationally.

However, a project team or consortia might be composed of scientists already working at the specific university or partner organisations involved. In this case, the relevant reference to be considered should be drawn from the statistics available at these universities or consortium partners. Relevant benchmark-indicators could be:

- **Proportion of researchers** by gender in all partner organisations and by broad und narrow fields of R&D.
- **Proportion of doctoral graduates** by gender in all partner organisations and by broad und narrow fields of R&D.
- **Proportion of professors** by gender in all partner organisations and by broad und narrow fields of R&D.

The advantage of such data is that they are very close to the consortia and even if not published, most of the organisations should have gender related data. The values of the indicators (e.g. share of women among doctoral researchers in Biomedicine) can be collected for each university or partner-organisation of the consortia. The values can serve as a benchmark corridor for women's participation within the project team. However, a few challenges arise:

- **Not standardised:** Unlike publications like "She Figures 2018" which provide standardised and comparable data, research organisations collect their data based on different classifications. There is no standardised monitoring system for all universities. Therefore, the indicator values that are collected in two different organisations may express similar things but may be different in detail (e.g. concerning the classifications of field of research, the definition of professorships, PhD students vs. doctoral graduations). Due to this lack of standardisation, one must be careful while interpreting the data.

- **Big consortia:** Sometimes, especially if consortia consist of many partner organisations, the compilation of data can be a time-consuming exercise. A possible way to solve this problem could be to benchmark data only from selected (leading) partners.
- **Interdisciplinary consortia:** Problems also arise in interdisciplinary research groups, since the average of women's participation differs significantly between research areas. This issue is not easy to handle. Using average values across a range of disciplines might lead to false conclusions, as particularly high and low values will cancel each other out. In large consortia, each discipline could be analysed separately, whereas in small consortia, it is difficult to derive adequate values. In this case, it could be an option to focus on one core discipline within the project.

These limitations do not mean that collecting data directly from partner organisations is of no use. The contrary is the case. The data give a close-to-project-view of the gender balance of the partner organisations which can be benchmarked against the data of the project team. However, data must be interpreted with caution, due to the mentioned limitations which result from the bottom up data collection.

2.3 CASE STUDY REFERENCE DATA FOR COMPUTER SCIENCES

Having discussed existing data sources and possible indicators, we propose to look at all these indicators, as there is no one perfect solution. Going one step further, we now set out to test if and how this is feasible for a hypothetical research consortium. We have chosen computer science (or ICT – Information and Communication Technology), as a field of science where women are a minority. With the intention to be as realistic as possible when choosing specific organisations for a hypothetical consortium, we considered the "Neurorobotics Platform", which is one of the eight main subprojects of the "Human Brain Project" (HBP)[16]. Neurorobotics in general is interdisciplinary, including specialist fields of computer sciences and drawing on the connection with brain research to understand and implement aspects of motion and sensation, learning and reasoning. Eight organisations from six countries are listed as partners of this platform[17]:

- Ecole Polytechnique Fédérale de Lausanne (EPFL) (CH)
- Technische Universität München (TUM - Robotics and Embedded Systems) (GER)
- Fortiss, an-Institut der Technischen Universität München (Fortiss) (GER)
- Forschungszentrum Informatik am Karlsruher Institut für Technologie (FZI) (GER)
- SSSUP - Instituto di BioRobotica (Scuola Superiore Sant'Anna) (IT)
- Universiteit Gent (BE)
- Universidad de Granada (ES)
- Technical University of Denmark – DTU (DK)

AVAILABLE DATA

For the analysis on a detailed level, we used the field "Computer (and Information) Science" or "Information and Communication Technology", where available. According to the Frascati Manual (OECD 2015), this is part of Natural Sciences as one of six broad fields of research and development ("FORD").

The following data sources could be used:

- **Country-level:** For the benchmark on country level data from "She Figures 2018" and partly "Elsevier" were useful. For the latter only data are available for EU-28 for "all sciences" (aggregated) as well as for "Computer Sciences". Data from the "UNESCO science report" were too unspecific to be helpful (gender related data for the partner-countries are only available in an aggregated way for "all sciences", data are provided as rather broad ranges, e.g. share of women in all sciences in Germany between 25%-34,9%). Therefore, data from the UNESCO report have not been included in the data compilations.
- **Organisational level:** For this paper, we only conducted desk-research of online available data and did not contact every research organisation directly asking for gender related data. Desk research showed that only two partner organisations (EPFL, TUM) have published gender-related data online. The partner organisation FORTISS as a so called "an-Institut" can in this respect be considered as part of the TUM. Therefore, data are available for three organisations. The definition of the published indicators varies between the organisations. For example, the TUM publishes "completed promotions" while for EPFL the "number of PhD-Students" are published. There are also differences in the classification of the research fields. While data from TUM focus on "Informatik", data from EPFL cover the fields of "Computer and Communication Sciences". Therefore, data allow only a rough benchmark.
- **Publication:** In the Leiden-Ranking six of the eight partner organisations are included.

The benchmark for women's participation reveals the following picture.

SHARE OF WOMEN RESEARCHERS IN GENERAL:

The Elsevier Gender Report (2017) shows that the proportion of women as researchers (2011-2015) in EU-28 reaches 41% for all sciences (aggregated) and 22% for Computer Sciences specifically.

16 The Human Brain Project is one of three EU FET Flagships. "FET Flagships are part of the Future Emerging Technologies (FET) programme, which invests in transformative frontier research and innovation with a high potential impact on technology, to benefit our economy and society." (see https://ec.europa.eu/digital-single-market/en/fet-flagships 25th October 2019)

17 https://neurorobotics.net/partners.html (5th September 2019)

DOCTORAL GRADUATES:

- **Country-level:** For all sciences (aggregated), the share of women doctoral graduates in the mentioned countries varies between 38% (CH) and 52% (IT), while in the fields of studies of ICT the share of women graduates is between 15% (GER) and 25% (IT). (SHE Figures 2018)
- **Level of Organisations**: Available data of the organisations show a share of between 13% to 21% of women in computer-related sciences which is a similar range like in the country-benchmark. (SHE Figures 2018)

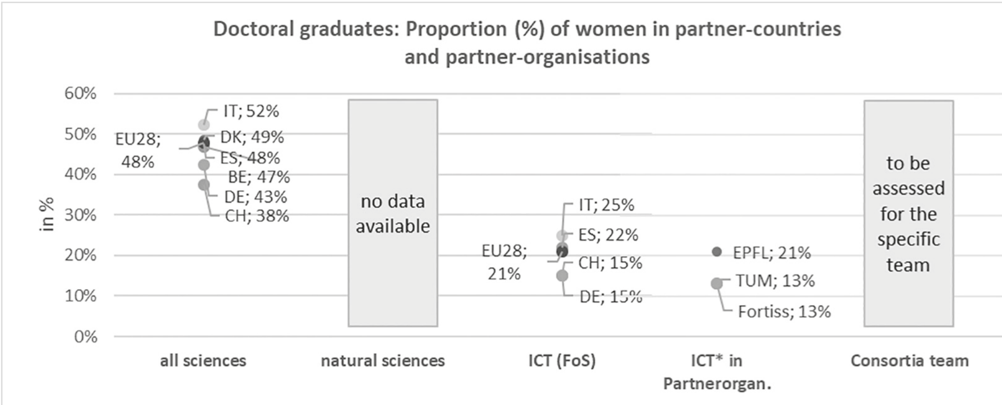

Figure 1: Doctoral graduates: Proportion (%) of women in partner-countries and partner organisations
Source: She Figures 2018, data for 2016, annual reports of partner-organisations, * TUM/Fortiss: completed promotions in "Informatik", * EPFL: Computer and Communication Sciences.

PROFESSORS

- **Country-level:** The share of women within the career stage of Professors (Grade A[18]) varies between 16%-22% for all sciences (aggregated) and is almost the same for natural sciences. No data on narrow fields (e.g. ICT) are published in the "She Figures". (SHE Figures 2018)
- **Level of Organisations:** Data for the organisations show that in ICT-related fields women's share among professors reached not more than 8% (for TUM C4/W3 Professorships, EPFL full professors).

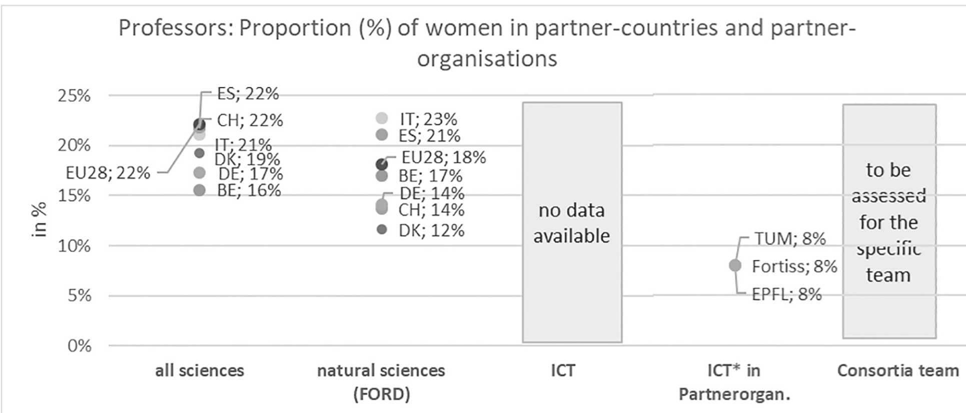

Figure 2: Professors: Proportion (%) of women in partner-countries and partner-organisations
Source: She Figures 2018, data for 2016, annual reports of partner-organisations, * TUM/Fortiss: completed promotions in "Informatik", *EPFL: PhD-students in "Computer and Communication Sciences".

18 As discussed above, Grade A either corresponds to the rank of full professor, or to the highest post at which research is normally conducted. (SHE Figures 2018, p.118, p.190, and, for details on national level, p.194ff)

PUBLICATIONS (LEIDEN-RANKING)

The Leiden Ranking shows that the number of women authors as a proportion of all publications of the organisations varies for all sciences (aggregated) between 16% and 35% and for "Mathematics and computer science" between 11% and 19%. As mentioned above, this could be used as a rough reference value to compare with the share of women in a specific research or project team.

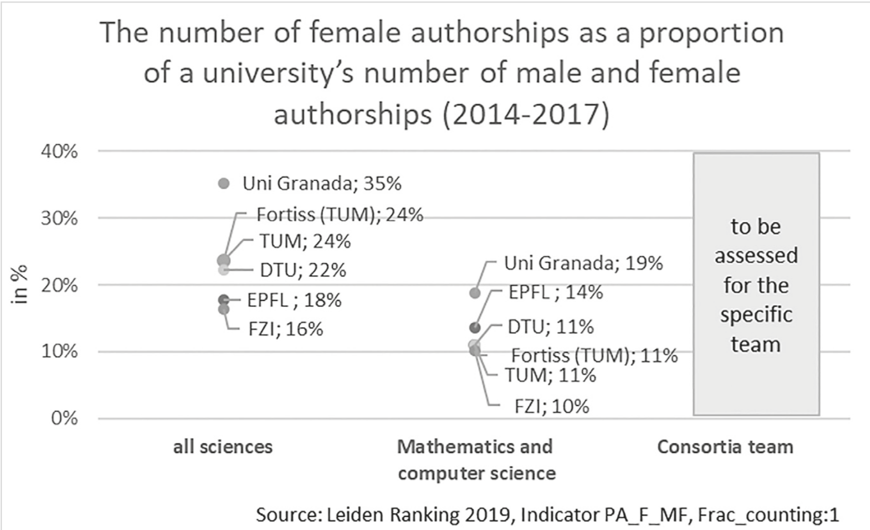

Figure 3: "The number of female authorships as a proportion of a university's number of male and female authorships (2014-2017)"
Source: Source: Leiden Ranking 2019, Indicator PA_F_MF, Frac_counting:1

CONCLUSIONS OF THE CASE STUDY

It was shown how benchmarks and reference values can be derived for the ICT field and specific research organizations. We summarize our findings on women's participation as follows:

- While the aggregated proportion of women researchers (2011-2015) in all sciences reaches 41% (EU-28), in the field of Computer Sciences one of five researchers (22%) is a woman.
- For doctoral graduates, data reveal that in ICT fields, women's proportion is considerably lower than in all sciences aggregated. The partner organisations considered in the case study are no exception. The participation of women is about the same as in the ICT research fields at national level.
- At the professors' level, the data show that the proportion of women in the natural sciences is slightly lower than in all scientific disciplines (aggregated). For the narrow fields of ICT no national data are available. Among the partner organisations for which data are available, we know that only 8% of ICT professors are women.
- The publication data of the Leiden Ranking show that, depending on the partner organisations, the proportion of women in publications in the field of "Mathematics and Informatics" is between 10% and 19%. For all partner organisations, the data show that the proportion of women in this scientific field is lower than for all scientific disciplines (aggregated).

Based on these empirical results, the question arises which target values are appropriate to assess the proportion of women contributing in a specific team. The indicators analysed span minimum and maximum values for different career levels (see Table 3 below). To provide the "missing element" and complete the assessment in this case, gender ratios within the actual project team would have to be collected: for the team overall, for leadership positions (professor-level) and doctoral graduates as a basis to compare with the reference values.

A project consortium not reaching minimum values should carefully reflect all possible reasons. It might conclude that some of the partners contribute with specific fields, e.g. related to infrastructure or theoretical computer science in which even less women are actively contributing. If this is not the case, measures to counteract should be taken immediately. In doing so, any support available at the research institutions, or on regional level should be considered.

Career Level	Minimum value		Maximum value	
	% of women	Based on	% of women	Based on
Doctoral and postdoctoral positions	13%	ICT, Partner Institution with lowest value	25%	ICT Graduates in Italy
Principal Investigators	10%	Women as authors in the Leiden Ranking (Mathematics and computer science), partner institution with lowest value	19%	Women as authors in the Leiden Ranking (Mathematics and computer science), partner institution with highest value
Leading position in project consortia or subprojects	8%	Women Professors in ICT at partner organisations	23 %	Women professors of natural sciences in Italy

Table 3: Comparative figures for women in ICT at different career levels

3. SUMMARY AND CONCLUSIONS

The aim of this paper is to make an evidence-based contribution to the question of an accurate gender-balance in research teams. We have reviewed existing international data sources that cover gender-specific data in research and assessed the usefulness of these sources. The findings can be summarized as follows:

- A suitable data source for our purpose should fulfill several critieria. It should cover women's proportion among researchers (i) along fields of research, (ii) across countries / organisations or (iii) carreer levels. Another important question is (iv) if the data source and respective reports are updated regularly.
- There are several sources dealing with gender-related data in research. But as far as we know, none of them covers all mentioned criteria at once. Most sources are severely limited in the availiability and comparability of the gender data. This is, among others, due to the complex interplay of different definitions (e.g. regarding fields of study/research or career levels), foci on different levels (e.g. international scientific community in a specific field, national or organizational level) and lacking regularity of reports.
- For our purpose, at least two conditions had to be met in order to be included in a more detailed analysis. The data source had to cover gender-specific data for more than one country as well as for different fields of research or study. According to these criteria, we analysed four sources in detail: (i) the "SHE Figures" report published by the European Commission every three years (latest release "She Figures 2018" in February 2019), (ii) "Gender in the Global Research Landscape" published by Elsevier in 2017, (iii) "UNESCO Science Report" (2015) and (iv) "CWTS Leiden Ranking", which is published annually.
- According to our research, the " She Figures" report has proven to be the most useful database.
- Generally, the more specific the indicators, the less likely it is that current data are actually available. For example: In the "She Figures" report, the shares of women among PhD-students are published at the level of narrow fields of studies for the natural sciences, ICT and engineering. Data for all other fields of study are only reported in broad categories. With regard to professors, the available data cover only broad fields of research (such as natural sciences, humanities, etc.) and no detailed information is found at all.
- As a consequence, for many research fields, publications like the "She Figures" report will not be enough to derive meaningful data for an assessment of gender-balances in specific research teams, projects or consortia. To overome this shortage, data must be collected directly from partner organisations to get an idea about women's proportion at different career stages and for specific research fields. Furthermore, an additional literature research focusing on the specific scientific fields of interest can prove useful. Various scientific communities or professional organisations occasionally publish gender-related studies or reports for their specific fields.
- The case study revealed that some, but not all, organisations publish detailed gender-related data. In this paper we limited our research on data which are available online. We suppose that the lack of available data at the level of partner organisations would be reduced within "real" consortia, i.e. when having access to internal data of organisations. Today all organisation monitor their human ressources in some way. So, even if the data are not published explicitly, there should at least be internal information within the organisations. Therefore, it should be possible for project partners to collect relevant indicators within their own organisation.

What steps need to be taken if a consortium team wants to assess its own gender relations against benchmarks, as proposed in this paper?

- First, one has to collect the relevant benchmark data. In this paper we have discussed a number of possible data sources as well as existing indicators. We are convinced that a combination of international data sources with bottom-up collected data of research partner organisations can give an apropriate overview of the actual participation of women in specific research fields, as well as on different career levels (PhD, professors). These data can be considered as a benchmark and provide an evidence-based starting point of discussion. They can be compared with a team's or consortium's actual shares of women and men to assess the status quo.

- Second, based on this data-evidence, within a research-team (or an entire organisation), it should be discussed: What is our goal regarding the participation of women and men?

    - Is it enough to be among average countries/organisations in the field? In this case, the average values of the benchmark indicators can be used as **"lower threshold"**.
    - Or do we want to challenge ourselves and set more ambitious goals to reap the potentials of a more balanced team composition? In this case, the research team could follow the best in the field as **"upper threshold"** of the benchmark, or strive to go even beyond. We have referenced the University of Manchester (University of Manchester – Department of Computer Science 2019). Another frequently cited example is the Harvey Mudd College in the USA, where College President Maria Klawe managed to reverse the trend of declining participation of women in computer science (see Harvey Mudd College 2019, Nickelsburg 2019).

This could also be a reasonable requirement by funding agencies, if they adapt the values to the respective scientific field or thematic areas. However, reaching the upper threshold ("best in class") or even an unreflected 50:50 as a binding criterion for research projects does not seem practical. Funding agencies could instead start to compensate those applicants who voluntarily strive for more ambitious goals with additional resources for the necessary additional efforts.

In discussions about an accurate share of women in research teams, it is often argued that the "pool" of suitable researchers is limited. The case study presented in this paper shows for the example of ICT that there is no single and "true" benchmark value. We rather find ranges of values depending on different countries or organisations. For example, the proportion of women PhD researchers in the countries in question varies between 15% and 25% (field of ICT). To estimate if there are really restrictions in the acqusition of women, it is good to be informed about these ranges in the specific fields of research. If the proportion of women in a research team is at the lower end of these ranges, the argument that their share cannot be higher due to a lack of suitable researchers is probably not the whole truth. The persuasiveness of this argument, however, increases when a research team is already positioned at the upper end of the spectrum. Ultimately, it is up to each team to decide how it wants to position itself within an international research community. The prerequisite for this is the knowledge of the actual proportion of women and men in the respective research areas in different countries or research organisations.

REFERENCES / LITERATURE

Bert, Alison (2018). 3 reasons gender diversity is crucial to science. Data reveals that the world needs more women in STEM; here's why. Elsevier Connect, October 1, 2018. https://www.elsevier.com/connect/3-reasons-gender-diversity-is-crucial-to-science

Butcher, Gilian; Chiu, Mei-Hung; Gledhill, Igle; Ivie, Rachel; Dawson, Silvina Ponce; Roy, Marie-Francoise (2019). An international and interdisciplinary project to analyze and help reduce the gender gap in mathematics and the natural sciences. AIP Conference Proceedings 2109, 030006 (2019); https://doi.org/10.1063/1.5110068

Elsevier (2015). Mapping Gender in the German Research Arena. https://www.elsevier.com/__data/assets/pdf_file/0004/126715/ELS_Germany_Gender_Research-SinglePages.pdf

Elsevier (2017). Gender in the Global Research Landscape. Analysis of research performance through gender lends across 20 years, 12 geographies, and 27 subject areas. Online: https://www.elsevier.com/__data/assets/pdf_file/0008/265661/ElsevierGenderReport_final_for-web.pdf

European Commission (2019). SHE FIGURES 2018. Directorate-General for Research and Innovation. Online:
https://ec.europa.eu/info/publications/she-figures-2018_en.

European Union (2019). Gender equality. Website Participant Portal H2020 Online Manual. https://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/gender_en.htm)

Grasenick, Karin (2019). Counting the numbers: what is a fair gender-balance in science projects? Blogpost from May 24th, 2019. https://www.ethicsdialogues.eu/2019/05/24/counting-the-numbers-what-is-a-fair-gender-balance-in-science-projects/

Harvey Mudd College (2019). About Harvey Mudd College – President Maria Klawe. Website.
https://www.hmc.edu/about-hmc/president-klawe/

Holman, Luke; Stuart-Fox, Devi; Hauser, Cindy E. (2018). The gender gap in science: How long until women are equally represented? PLoS Biol 16(4): e2004956. https://doi.org/10.1371/journal.pbio.2004956

Leiden Ranking (2019). CWTS Leiden Ranking 2019. Centre for Science and Technology Studies. Leiden University.
Website. https://www.leidenranking.com/

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2007). Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering. Washington, DC: The National Academies Press.
https://doi.org/10.17226/11741.

Netzwerk Frauen- und Geschlechterforschung NRW (2019). Gender-Report der Hochschulen in NRW. Website. http://www.genderreport-hochschulen.nrw.de/start-genderreport/

Nickelsburg, Monica (2019). Harvey Mudd President Maria Klawe has a message for computer science grads — and the tech industry. GeekWire Podcast, June 13th, 2019. https://www.geekwire.com/2019/harvey-mudd-president-maria-klawe-message-computer-science-grads-tech-industry/

OECD (2015). Frascati Manual 2015. Guidelines for Collecting and Reporting Data on Research and Experimental Development. https://www.oecd.org/publications/frascati-manual-2015-9789264239012-en.htm

PLOTINA (2015). Promoting gender balance and inclusion in research, innovation and training. Project funded by EU Horizon 2020 (grant agreement G.A NO 666008). https://www.plotina.eu/

Ranga, Marina; Gupta, Namrata; Etzkowitz, Henry (2012). Gender Effects in Research Funding. A review of the scientific discussion on the gender-specific aspects of the evaluation of funding proposals and the awarding of funding http://www.dfg.de/download/pdf/dfg_im_profil/geschaeftsstelle/publikationen/studien/studie_gender_effects.pdf

SAGE (2019). Science in Australia Gender Equity initiative. Website. www.sciencegenderequity.org.au/about-sage/

Schiebinger, Londa; Klinge, Ineke; Sánchez de Madariaga, Inés; Paik, Hee Young; Schraudner, Martina, and Stefanick, Marcia (Eds.) (2011-2018). Gendered Innovations in Science, Health & Medicine, Engineering and Environment. http://genderedinnovations.stanford.edu/what-is-gendered-innovations.html

Staats, Cheryl; Capatosto, Kelly; Tenney, Lena & Mamo, Sarah (2017). State of the Science: Implicit bias review. Kirwan Institute. http://kirwaninstitute.osu.edu/wp-content/uploads/2017/11/2017-SOTS-final-draft-02.pdf

Technische Universität München (2018). Diversity -Reader der Technischen Universität München. Ausgabe 1/2018. https://www.chancengleichheit.tum.de/fileadmin/w00blt/www/Download/Publikationen/TUM_Diversity_Reader_2018_-_v04.pdf

The Lancet (2019). Advancing women in science, medicine, and global health. Vol. 393, Nr. 10171, p493-610, e6-e28, Feb 09, 2019. https://www.thelancet.com/journals/lancet/issue/vol393no10171/PIIS0140-6736(19)X0006-9#

UNESCO (2015). UNESCO Science Report: towards 2030. https://en.unesco.org/unesco_science_report

UNESCO Institute for Statistics (2019). UIS Statistics Database – Science, technology and innovation. http://data.uis.unesco.org/

UNESCO Institute for Statistics (2014). ISCED Fields of Education and Training 2013 (ISCED-F 2013). Manual to accompany the International Standard Classification of Education 2011. http://dx.doi.org/10.15220/978-92-9189-150-4-en

University of Manchester – Department of Computer Science (2019). Women in computer science. https://www.cs.manchester.ac.uk/about/women/

University of Manchester (UOM) (2019). Equality Information Report 2019. http://documents.manchester.ac.uk/display.aspx?DocID=35595

World Economic Forum (2018). The Global Gender Gap Report 2018 (Focus: AI). https://www.weforum.org/reports/the-global-gender-gap-report-2018

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