Visual summary of gender equality in STI

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GENDER STI

This document introduces results in visual format from two big data exercises of Gender STI project task 1.3 Big data analysis of the role of women in STI.

We explore role of

- female inventors in Artificial Intelligence (AI) patents that helps us to understand diversity in a fast developing technology area, and
- gender equality in science, technology and innovation (STI) policies that reveals us a progress of gender equality mainstreaming in STI policy making worldwide.

- In addition to this document, the results will be disseminated via Gender STI Observatory (https://www.gender-sti.org/european-observatory-on-gender-in-sti/)

D1.5 Visual summary of gender equality in STI

What do AI patents and STI policies say about gender-equality?

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Arash Hajikhani

31.10.2023

Gender STI

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Gender STI

Section I: Gender equality in artificial intelligence

1. Artificial intelligence

    1.1 Gender equality in AI - Does AI advance gender equality?

2. AI Patents

    2.1 Data and methodology

    2.2 Results of AI patent analysis

Section II: Gender equality in STI policies

1. STI policy documents

    1.1 Data and methodology

    1.2 Results STI policy document analysis

Gender STI

Section I:
Gender equality in artificial intelligence

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For a reader:

- This document introduces results in visual format from two big data exercises of Gender STI project task 1.3 of Big data analysis. We explore role of
    - female inventors in AI patents, and
    - gender equality in science, technology and innovation (STI) policies.

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Gender STI+

Integrating Gender Sensitization in Research and Technology

- Today, women and girls are 25 per cent less likely than men to know how to leverage digital technology for basic purposes, 4 times less likely to know how to programme computers and 13 times less likely to file for a technology patent. (source: UNESCO, 2019*)

- Danger is that today's gender stereotypes are built into tomorrow's technological systems and widen gender gaps.

Source: UNESCO, 2019. I'd blush if I could: closing gender divides in digital skills through education. https://unesdoc.unesco.org/ark:/48223/pf0000367416.page=1

Artificial intelligence, quantum computing based futured is not yet fully here, but it is just around the corner.

Gender STI

1. ARTIFICIAL INTELLIGENCE (AI)

In a male-dominated digital world, have half the population's needs taken a back seat?

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Why AI is important?

- Artificial intelligence (AI) involves using computers to classify, analyze, and draw predictions from data sets, using a set of rules called algorithms. AI algorithms are trained using large datasets so that they can identify patterns, make predictions, recommend actions, and figure out what to do in unfamiliar situations, learning from new data and thus improving over time. The ability of an AI system to improve automatically through experience is known as Machine Learning (ML). (UNESCO, 2020)

Why AI is a hype?

- Development and use of generative AI models, like ChatGPT, has boomed.

- AI is an overarching technology and affects majority of industries and sectors - **35% of industries apply AI***.

- Integration of AI will change professions (low and high-skilled professions) in future.

<u>Source:</u> * IBM Global AI Adoption Index 2022

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Number AI publications increase fast
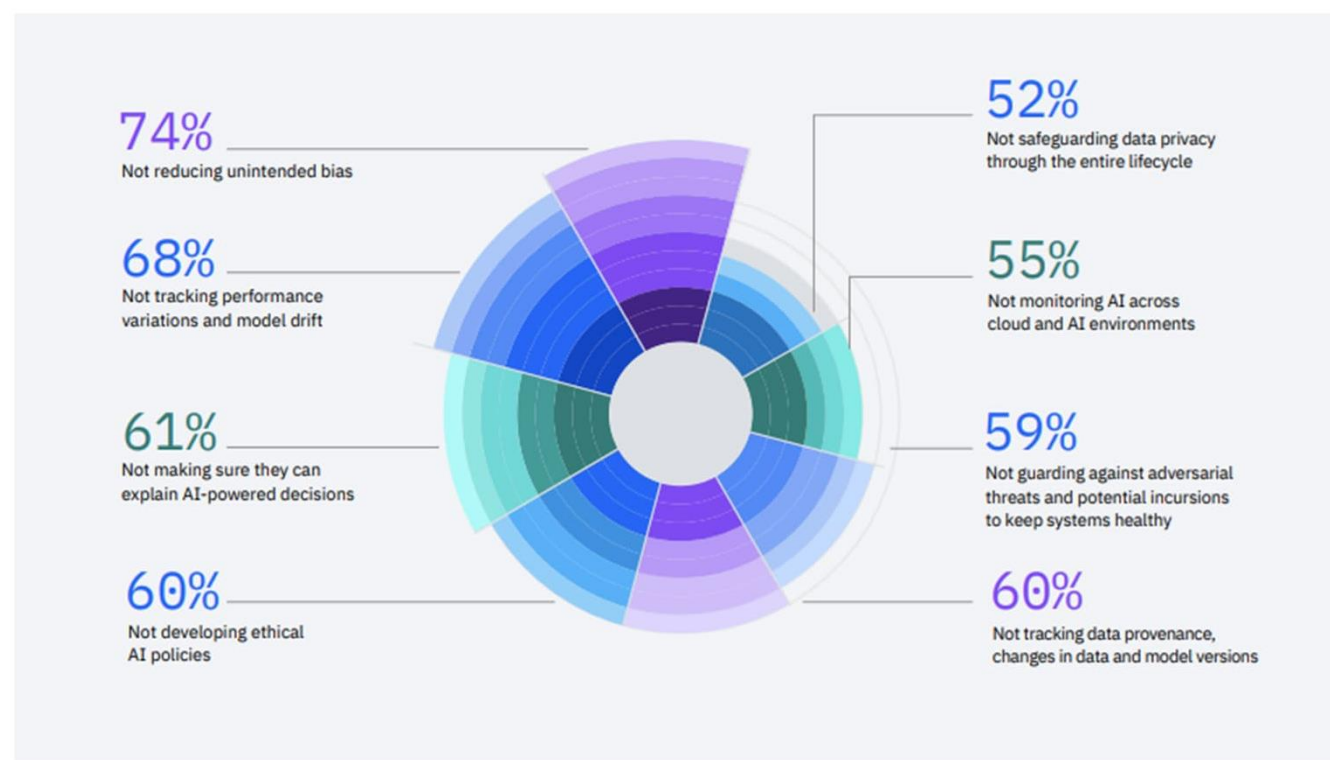

Source of data: OpenAlex
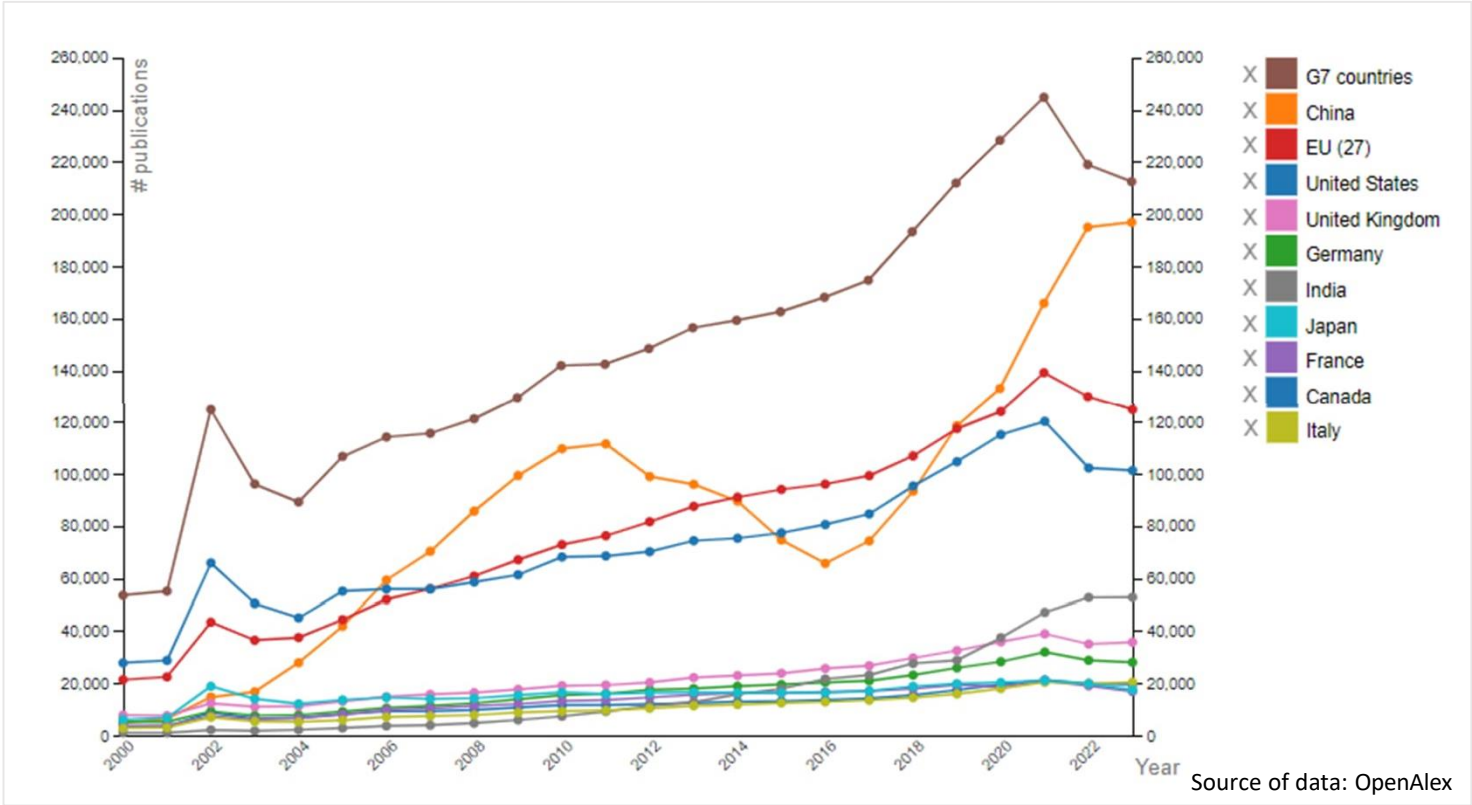
- The total number of AI publications has more than doubled in past 10 years.
- AI research collaboration is dominated by the United States and China, and the United Kingdom and China.
- According to ArXiv data, 14% of authors are female (Stathoulopoulos & Mateos-Garcia, 2019).

Sources:
OECD.AI (2023), visualisations powered by JSI using data from OpenAlex., accessed on 28/9/2023, www.oecd.ai
Artificial Intelligence Index, 2023. Stanford Institute for Human-Centered AI

Why AI can be discriminating and inequal?

- Companies struggle with trustworthy AI.

- To develop responsible and ethical AI, it needs to avoid perpetuate prejudice by e.g.
    - Carefully selecting training sets to avoid biases in algorithms.
    - Ensuring AI development include interdisciplinarity

74% Not reducing unintended bias

68% Not tracking performance variations and model drift

61% Not making sure they can explain AI-powered decisions

60% Not developing ethical AI policies

52% Not safeguarding data privacy through the entire lifecycle

55% Not monitoring AI across cloud and AI environments

59% Not guarding against adversarial threats and potential incursions to keep systems healthy

60% Not tracking data provenance, changes in data and model versions

A majority of organizations haven't taken key steps towards trustworthy AI.

Source: * IBM Global AI Adoption Index 2022

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1.1 Gender equality in AI - Does AI advance gender equality?

Gender STI

Key challenge is that over a third of companies employ artificial intelligence (AI) to optimise and automate their operations.

Women only make up 22% of the global AI workforce.

What happens when women are excluded from the AI lifecycle?

Gender gap in AI development and design

Women a minority in Industry 4.0 fields

- Women represent only 33% of science R&D positions globally (UNESCO, 2021).

- Only 30% of AI professionals were women in 2022. In 2016, the figure was 26%. (WEF, 2023)

- In 2021, 30 % were female in new information faculty hires in North America (AII, 2023).

- AI development is North American and advanced economies led thus reflecting Global North perspective.
  - As social and economic contexts vary by country, this lack of regional representation can exacerbate inequalities in the ethical design and deployment of AI.

Sources:
WEF (2023) Global Gender Gap Report. https://www3.weforum.org/docs/WEF_GGGR_2023.pdf
UNESCO (2021) UNESCO SCIENCE REPORT: The race against time for smarter development. Chapter 3: TO BE SMART, THE DIGITAL REVOLUTION WILL NEED TO BE INCLUSIVE
https://www.unesco.org/reports/science/2021/en/women-digital-revolution
Artificial Intelligence Index (AII), 2023. Stanford Institute for Human-Centered AI, AI Index Report 2023 – Artificial Intelligence Index (stanford.edu)

Gender gap in use of AI

ICT startups are dominated by men

- Only 19% of European ICT entrepreneurs are women. (EC, 2019)

- 93% of capital invested in European companies this year went to all-male founding teams. (EC, 2019)

Skill gap in ICT persists

- Women are 25% less likely than men to know how to leverage digital technology for basic uses. (UNESCO, 2022)

- AI is rapidly being integrated into both workplace and domestic settings. The use of AI technologies will affect women's opportunities for work, and their position, status and treatment in the workplace.

Sources:
EC (2019) Women in Digital. https://digital-strategy.ec.europa.eu/en/library/women-digital
UNESCO (2022) The Effects of AI on the Working Lives of Women.

Why inclusiveness is important in AI?

- Lack of diversity can lead to harms, among them the reinforcement of existing societal inequalities and bias – AI development in academia and industry is dominated by white males representing perspectives of Global North.

- AI development teams lacking diversity will be insufficiently aware of, or sensitive to, the risks of the technologies that they develop for other social (vulnerable) groups.

- Diversifying the workforce developing AI systems reduces the risk that AI generates discriminatory and unfair outcomes, thus ensuring that benefits of AI are more widely shared.

- Studies show that more diverse teams are performing better:
  - Diversity in teams correlates with stronger profit and exceeds market reference value (Christiansen et al., 2016).
  - Increased gender diversity correlates with higher productivity, innovations and value creation (McKinsey & Company, 2015; Nordea, 2018).

- EIGE (2022) suggest two main ways to improve the gender balance in the AI industry:
  1) close the gender divide in AI-related fields of education;
  2) focus on entry and retention of women in the industry.

Source: EIGE, 2022. Artificial intelligence, platform work and gender equality. https://eige.europa.eu/publications-resources/publications/artificial-intelligence-platform-work-and-gender-equality

2 AI Patents

Gender STI

Will the Fourth Industrial Revolution perpetuate
the gender imbalance?

Women's needs are likely to be neglected
in projects designed on the basis of big
data or social media data, like smartphone
applications, if women remain in minority
in academia and business.

2.1 Data and methodology

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AI patent landscape benchmark

- Data collection method and clustering scheme:
  - The data collection follows the categorization proposed by WIPO Technology Trends Report: Artificial Intelligence (2019).
    - AI techniques
    - AI functional applications
    - AI application fields

Query construction

- The search query contains key phrases, CPC (Cooperative Patent Classification) and IPC (International Patent Classification) symbols that can be used to carry out searches in PATENTSCOPE* and other patent databases.

- For our data retrieval, we have used Patbase API and therefore transformed the WIPO searching query for data identification, validation and retrieval

* https://patentscope.wipo.int/search/en/search.jsf
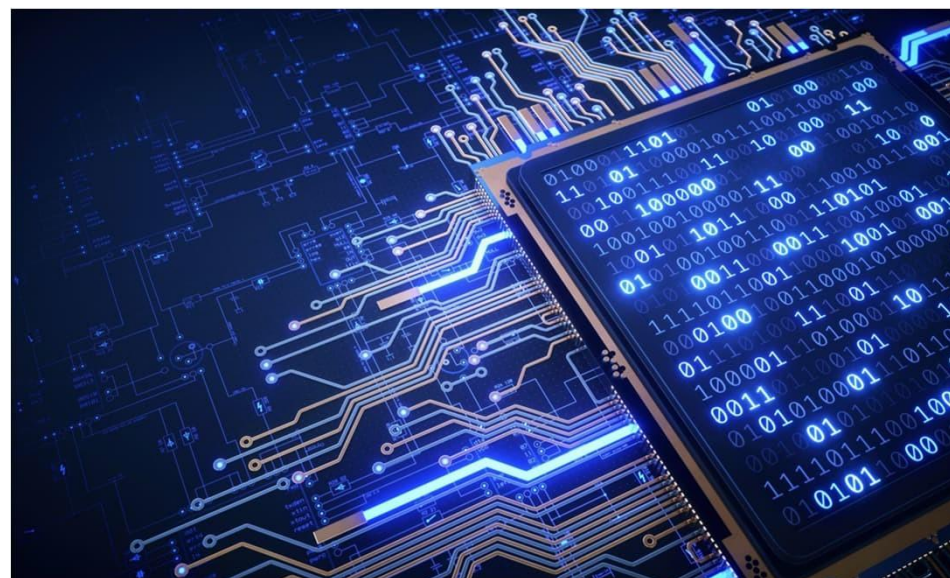
AI patents

- The query retrieved 791,695 patent families which have AI relevancy, published from beginning of 1990 until the end of 2021.

| Number of families: 791,695 (2,202,414 publications)	Number of publications (exactly matching the query): 1,674,066
Number of publications (when one document per application is selected): 1,285,837	
Number of unique countries: 94	Number of unique probable assignees: 138,263
Earliest publication date: 18400610	Latest publication date: 20221101
Earliest priority date: 18980701	Latest priority date: 20221015

2.2 Results of AI patent analysis

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Increasing Women contributions in Technological Inventions

- The identification of Artificial Intelligence (AI) related patents has been conducted using the codebook provided by the PATENTSCOPE Artificial Intelligence Index, which facilitates swift identification and exploration through streamlined access, structured categorization, and provision of key search phrases and patent classification symbols.
- In accordance with the corresponding query, we retrieved patent data from PATBASE dating back to 1990.

While the number of AI-oriented technology inventions has been increasing in the past few decades (as shown in the left diagram), the share of women's contributions to these inventions has also been on the rise (as depicted in the left diagram)
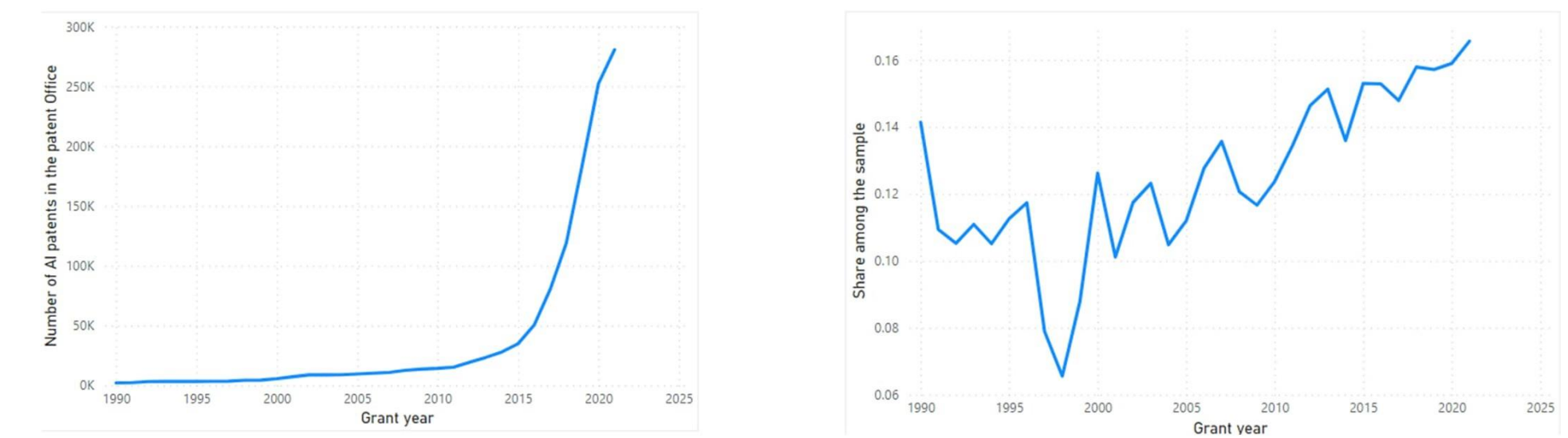
The conspicuous dip in 1998 can be substantially attributed to the limited number of AI patents in the early years, thereby exemplifying that **the potential for smaller sample sizes to introduce volatility in observed trends** should be cautiously acknowledged in interpreting the data.

Increasing Women contributions in Technological Inventions

- In overall, female inventors' contributions has increased in creation of AI technologies (left diagram).
- Although China patent office has registered the highest number of AI patents, the contrition of female inventors has not changed during the past years (middle diagram).
- USPTO data, has witnessed the highest growth in contribution of female inventors (right diagram).

All the patent jurisdictions

China Patent Office
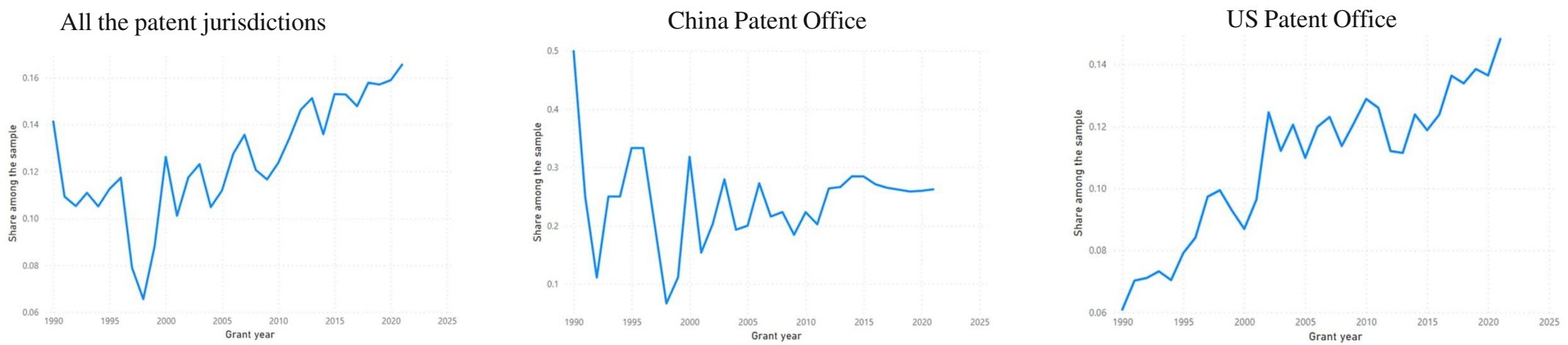
US Patent Office

Increasing Women contributions in Technological Inventions

In the USPTO, renowned as one of the most reliable patent offices, the number of AI patents has shown consistent growth in recent years. Additionally, the contribution of female inventors to this field has also been on the rise.

In our research, we delved into the disruptiveness of patents created by inventors of genders, including males and females. To measure disruptiveness, we relied upon a study conducted by Park et al. in 2023, published in Nature.

Our findings suggest a decrease in the overall disruptiveness of AI patents. However, it's noteworthy that there is no significant difference in disruptiveness between patents associated with male and female inventors.

Average of AI patents disruptiveness by first inventors geneder
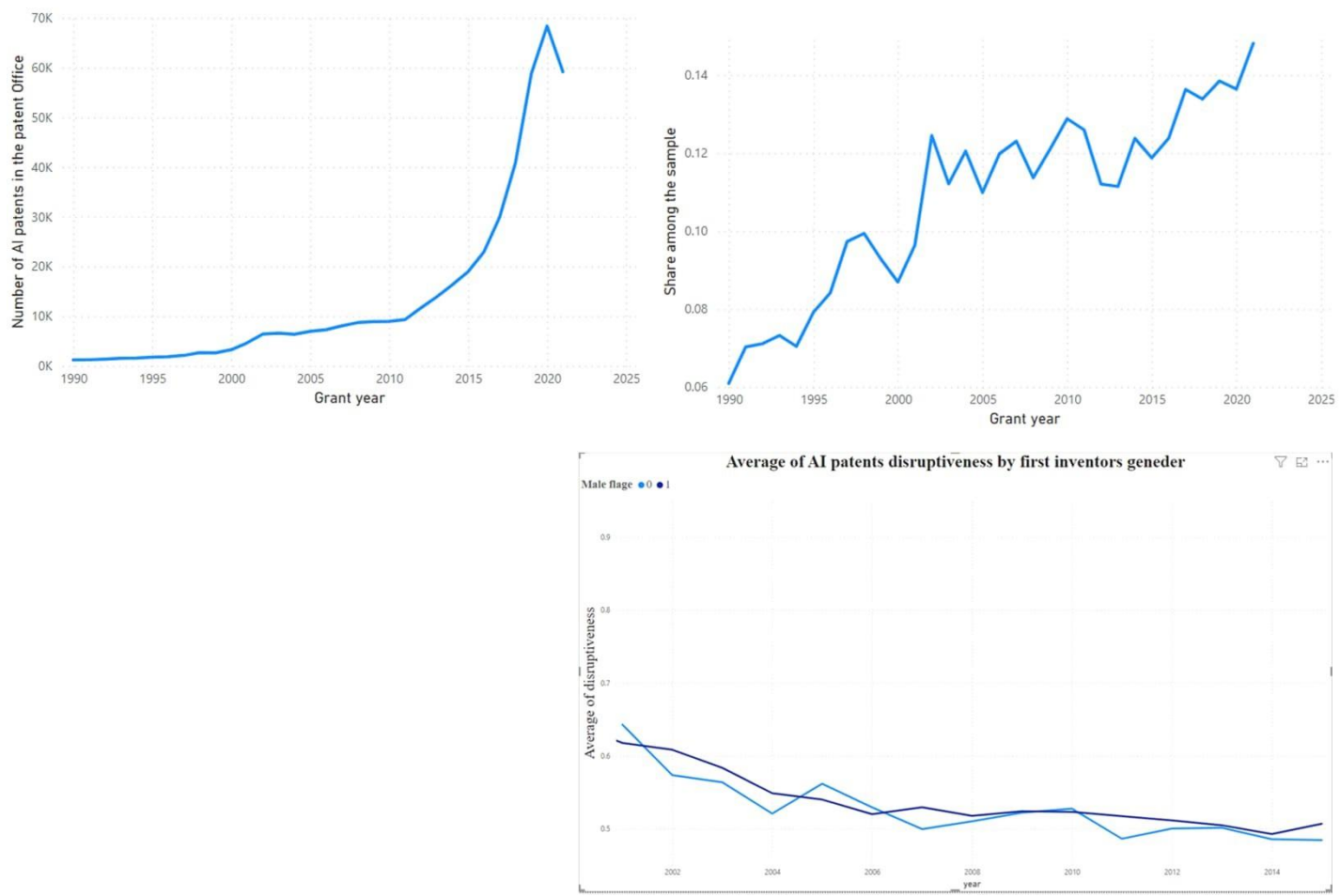
Gender STI

Concluding comments:

- AI as a fast-moving sector should pay emphasis on including gender equality and inclusiveness in the STI related Memorandum of Understandings and agreements to ensure diversity in AI development.

- AI ethics is often broad and blurry concept; therefore, it is suggested that AI developers and practitioners make ethics' dimensions more concrete, for example adding gender equality and inclusiveness aspects.

- It is important to encourage girls and women to STEM and IT fields by placing emphasis on their retention in the field of AI development, i.e. increasing diversity (and lowering masculinity) of AI working culture.

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Integrating Gender Sensitization in Research and Technology

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- EIGE (2022) Artificial intelligence, platform work and gender equality. https://eige.europa.eu/publications-resources/publications/artificial-intelligence-platform-work-and-gender-equality

- IBM Global AI Adoption Index 2022. https://www.ibm.com/downloads/cas/GVAGA3JP

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- Park, M., Leahey, E. & Funk, R.J. (2023). Papers and patents are becoming less disruptive over time. Nature 613, 138–144 (2023). https://doi.org/10.1038/s41586-022-05543-x

- UNESCO (2022) The Effects of AI on the Working Lives of Women. https://www.unesco.org/en/articles/does-artificial-intelligence-advance-gender-equality

- UNESCO (2021) UNESCO SCIENCE REPORT: The race against time for smarter development. Chapter 3: TO BE SMART, THE DIGITAL REVOLUTION WILL NEED TO BE INCLUSIVE https://www.unesco.org/reports/science/2021/en/women-digital-revolution

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- WEF (2023) Global Gender Gap Report. https://www3.weforum.org/docs/WEF_GGGR_2023.pdf

- WIPO (2019) WIPO Technology Trends Report: Artificial Intelligence. https://www.wipo.int/tech_trends/en/artificial_intelligence/

Section II:
Gender equality in STI policies

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1. STI POLICY DOCUMENTS

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Policy Documents

Policy documents play an important role in shaping the regulation and implementation of gender equality dimensions within research and innovation policies, particularly in the field of science, technology, and innovation (STI).

These documents provide a framework for addressing gender inequalities and promoting inclusivity in research and innovation.

They frame strategies, guidelines, and initiatives to overcome gender disparities and ensure that underrepresented groups are equally empowered to contribute to and benefit from advancements in science, technology, and innovation.

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What is STIP Compass?

(source: https://stip.oecd.org/stip/pages/about)

- STIP Compass is a joint initiative of the European Commission (EC) and the OECD that aims to collect together in one place qualitative and quantitative data on national trends in science, technology and innovation (STI) policy. The portal supports the continuous monitoring and analysis of countries' STI policies and seeks to become a central platform for policy research and advice supporting government officials, analysts and scholars. Through its various interfaces, you may seamlessly explore and download data to analyse country policies on a wide range of STI policy issues. Data is freely accessible following the FAIR principles (Findable, Accessible, Interoperable, and Re-usable).

Where does STIP Compass data come from?

- The main data source for STIP Compass is countries' responses to the EC-OECD STI Policy survey, which is run every two years. The most recent edition was administered in 2021. Data are collected under the auspices of the OECD Committee for Scientific and Technological Policy (CSTP) and the European Union's European Research Area and Innovation Committee (ERAC). The survey is addressed to national government officials working on STI policies in a range of public administrations (including ministries and agencies) using an online questionnaire tool based on the LimeSurvey open-source software.

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Gender STI

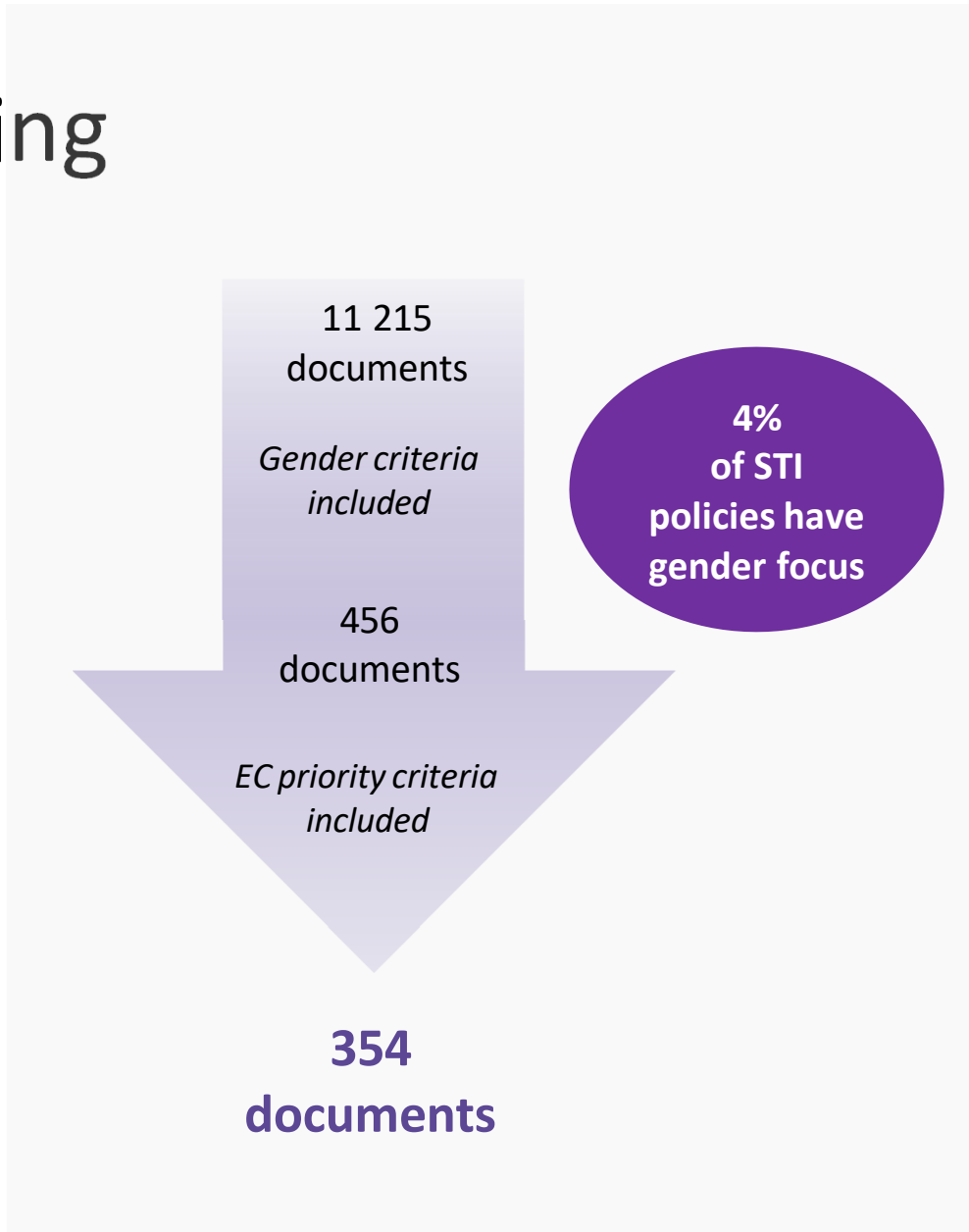# *1.1 Data and methodology*

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Description of data sampling

- We retrieved 11215 documents, 456 documents addressed gender dimensions, in the background, description or objectives. The identification of documents addressing gender issues has been developed based on certain search terms including ['gender','woman','women','inclusion','inclusiveness',´'lgbt','female']

- However, the selected documents discussed various aspects of gender issues. Out of these 456 documents, 354 documents addressed at least one of the three gender mainstreaming priorities proposed by EC.

- Analysis employed large language models to understand the discussion around the defined challenges within the document.

  PRIORITY 1: Gender equality in scientific careers

  PRIORITY 2: Gender balance in decision-making bodies and positions

  PRIORITY 3: Integration of the gender dimension in research and innovation content

11 215
documents

*Gender criteria
included*

456
documents

*EC priority criteria
included*

**354
documents**

**4%
of STI
policies have
gender focus**

Data-driven examination of the policy terrain related to gender in STI

The methodology involved:

- Utilizing the STIP Compass to extract policy descriptions, backgrounds or objectives with a substantive mention of gender aspects.

- Conducting Thematic Analysis to extract and analyze themes relevant to identified gender-related challenges in STI.

- Ensuring Alignment with three predefined challenges: gender equality in scientific careers, achieving gender balance in STI decision-making positions, and integrating the gender dimension in R&D&I content.

Through the meticulous filtering and analysis of data from the STIP Compass, this approach facilitated a focused and data-driven examination of the policy terrain related to gender in STI based on the large-language models, underscoring key policies and strategies pertinent to the addressed challenges.

Summary of Final Data Sample

354

Policy Documents

Prepared by **ministries** and **government departments**, **national** and **regional councils**, **research** and **funding agencies**, and **international organizations**.

Collected from **50 countries** across **6 continents**

The **target groups** are governmental entities, research and education organisations, economic actors (individuals and companies), researchers, students, and teachers.

Main **thematic areas** are: governance, research and innovation for society, public research, emerging trends in STI policy, knowledge transfer and sharing, innovative entrepreneurship.

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1.2 Results STI policy document analysis

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Policy instrument types

- In practice, policy documents can support gender equality in STI through various means. The majority of STI policy documents that have gender contents are STI strategies, agendas and plans (29%) which aim to steering national STI agendas to better integrate gender equality in different domains.
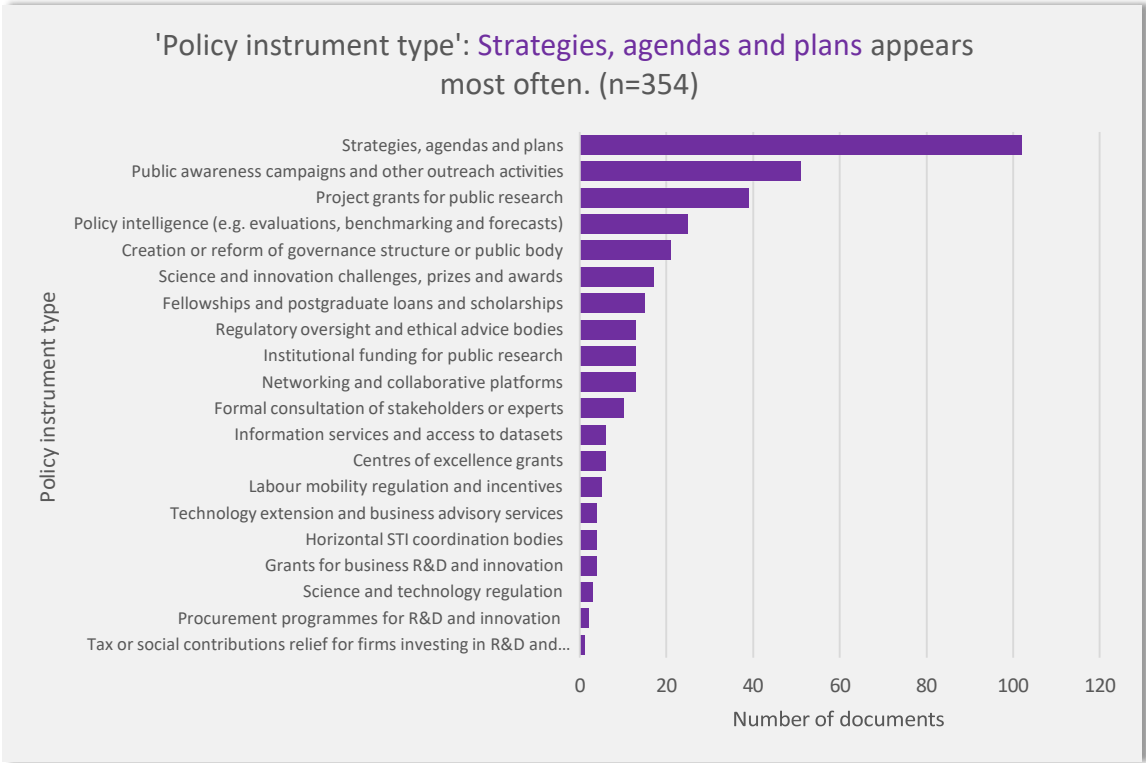
Targeted funding and support

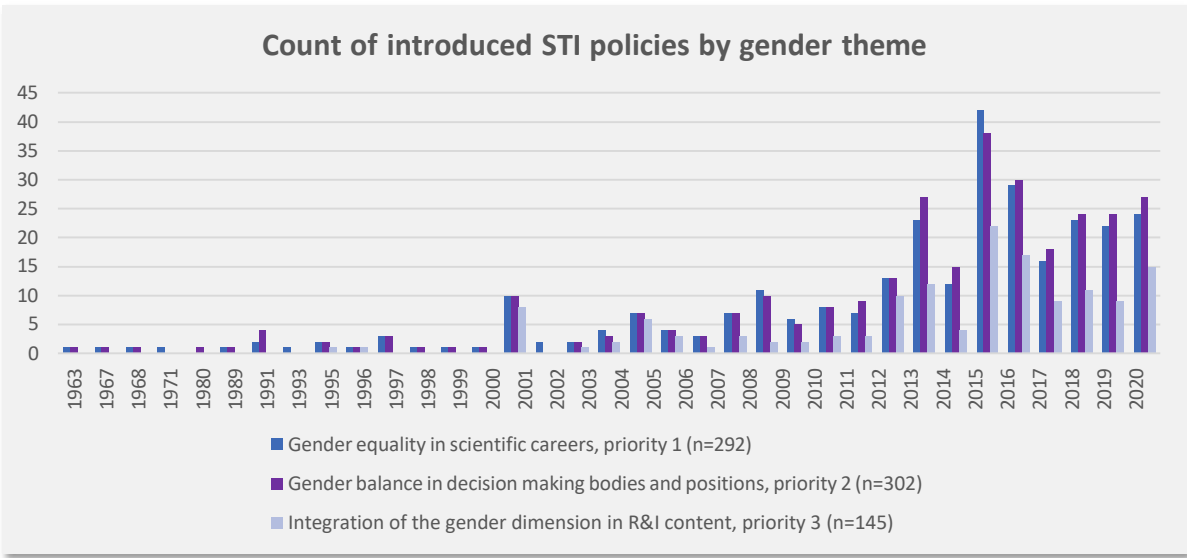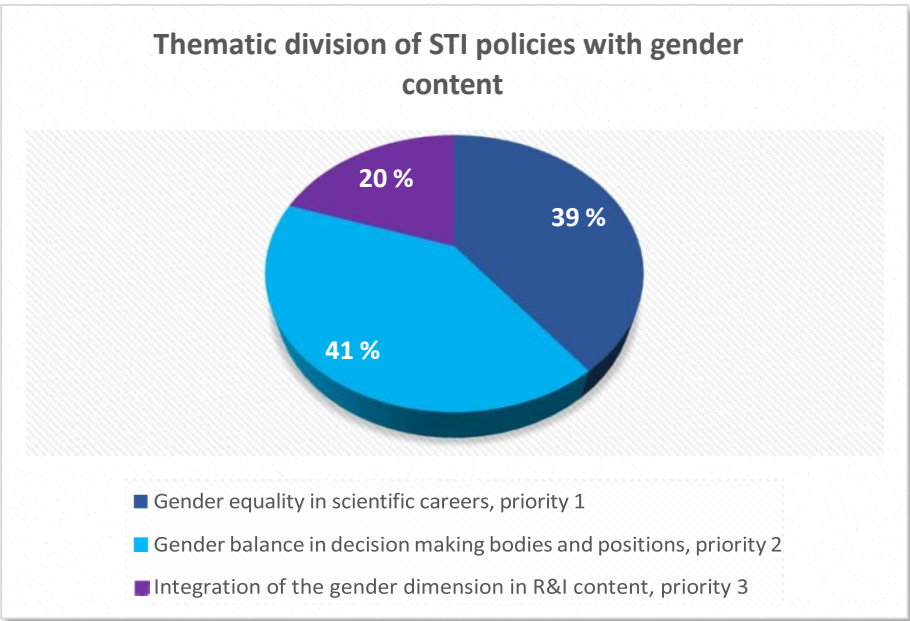**Request for gender-disaggregated data collection**

Promotion of good practices

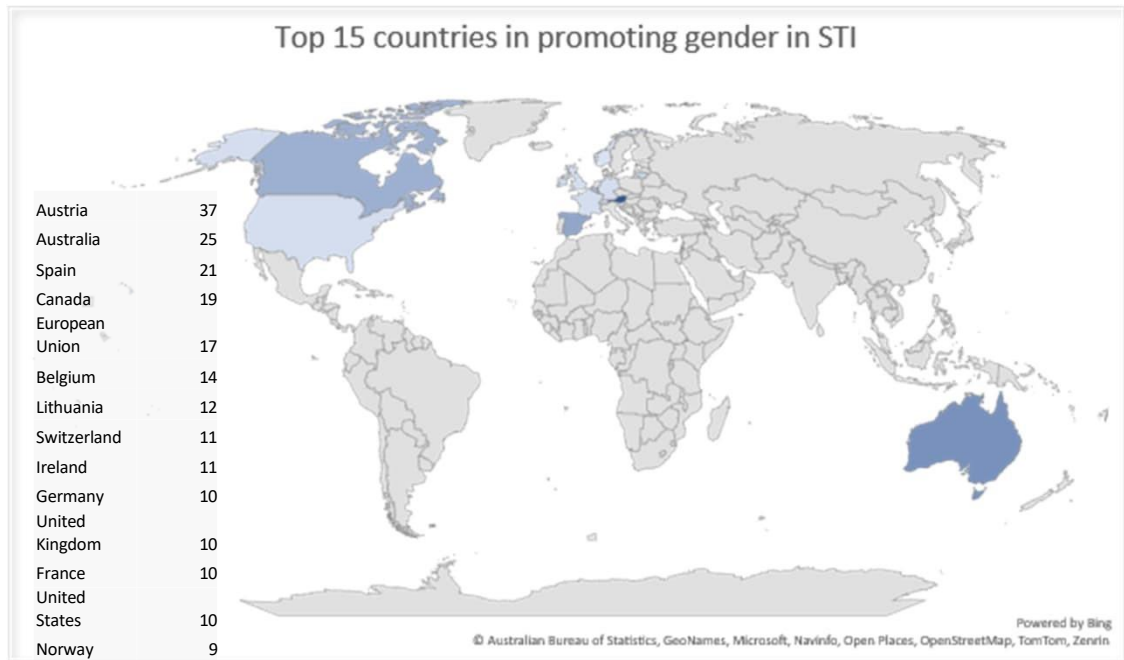**Support inclusive research content**

Promotion of institutional change

'Policy instrument type': Strategies, agendas and plans appears most often. (n=354)

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Gender objectives in STI policies

Thematic division of STI policies with gender content

- Gender equality in scientific careers, priority 1
- Gender balance in decision making bodies and positions, priority 2
- Integration of the gender dimension in R&I content, priority 3

Count of introduced STI policies by gender theme

- Gender equality in scientific careers, priority 1 (n=292)
- Gender balance in decision making bodies and positions, priority 2 (n=302)
- Integration of the gender dimension in R&I content, priority 3 (n=145)

- Only 4 % (354 out of 11 215 documents) of STI policies address gender and inclusiveness.
- Integration of the gender dimension in R&I content is significantly less addressed in STI policies than the other two priorities by EC.

# TOP 15 countries in promoting gender equality in STI

- **Austria**, **Spain**, **Australia** stand out in promoting gender equality through STI policies.

- Austria and Spain are prominent in promoting gender equality in Europe among **European Commission** initiatives, while **Canada** and Australia are leading countries outside Europe .

- However, many countries do not follow consistent policy in promoting gender equality in STI, given that 34% of countries in STIP data have less than 3 policies.

Top 15 countries in promoting gender in STI

Country	
Austria	37
Australia	25
Spain	21
Canada	19
European Union	17
Belgium	14
Lithuania	12
Switzerland	11
Ireland	11
Germany	10
United Kingdom	10
France	10
United States	10
Norway	9

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Good practices to promote gender in STI policies:

- To have stronger focus to context specific gender and inclusiveness: It is important to improve context specificity of the gender equality and inclusiveness actions to address specific challenges and barriers related to different fields and disciplines within STI.

- To improve STI policy incentives and agreements related to the integration of gender in research, development and innovation activities: actions that integrate sex and gender and inclusiveness in the R&I contents are needed.

- Adjust gender language in STI: Gender related language should be revised from gender equality to inclusiveness to better reach different groups (policy-makers, researchers, entrepreneurs, etc).

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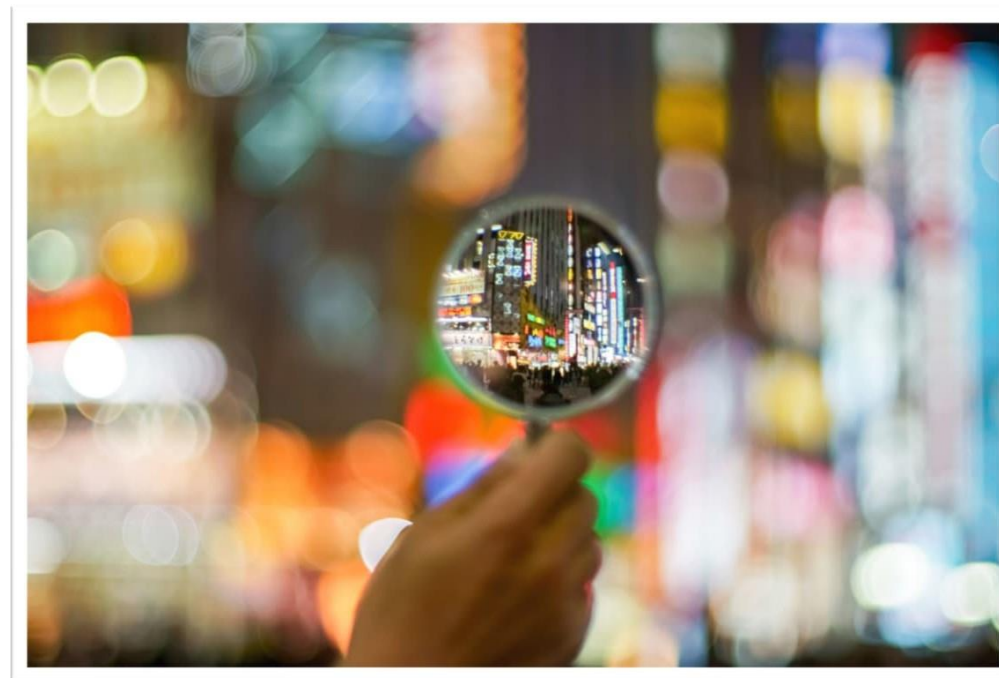
Citations:

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